# POWER

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## Greetings

By Berton Braley

CHRISTMAS and New Year's come closely together,
Here is a rousing good greeting for both,
Here's to your joy in this winter-time weather,
Here's to your health and your progress and growth.
May you keep body and mind in condition
Fine as a power plant perfectly run,
Never lack fuel to feed your ambition,
Always have steam up for what's to be done.

May you be one of the leaders and thinkers—
Brain burning clear as a newly-cleaned fire
Totally free of dead ashes and clinkers—
May you be one to achieve and aspire.
May you be strong when your worries redouble
(Christmas-time wishes can't keep them away),
May you stand up under peak loads of trouble,
Just as a dynamo does every day.

May your good humor eliminate friction,
Acting as oil on the bearings of life,
"Happy New Year" is a fact, not a fiction,
When you can smile in the midst of the strife.
May you have strength for the work that you follow
Measured in hp. and kilowatts too,
May the New Year beat the old one all hollow-
"POWER" is wishing *"more* POWER *to you"!*

# Moxley Plant Remodeled

By Thomas Wilson

*SYNOPSIS—Remodeling a boiler plant under difficulties. A comparison of the old and new installations indicates the advance made in the last 15 years in boiler-room practice.*

Back in 1901 W. J. Moxley, of Chicago, erected a large brick building that was to be devoted to the manufacture of butterine and a general cold-storage business. To furnish the refrigeration necessary, two 75-ton compressors driven by tandem-compound Corliss engines equipped with a condenser, and one 25-ton machine driven by a simple engine were installed. Two 125-kw. direct-connected units and one 45-kw. outfit were provided to generate current for light and power. The engines for the generators were operated noncondensing, as exhaust steam was required the year around in the manufacturing processes, and the larger ones are of the tandem compound single-valve type. The electrical load averages about 110 kw., so that ordinarily one large machine will carry the load during the day and the small engine the night load. The large compressor engines are operated condensing in the summer months, but in the winter the condensers are eliminated, as there is demand for all of the exhaust steam. In the hot weather it is necessary to run the two large compressors. One carries the low-temperature rooms and the other the high-temperature rooms at different back pressures. A cooling tower on the roof is provided for the condenser circulating water.

Besides the demand for steam just mentioned, considerable live steam is required in the manufacturing processes, and to supply the necessary amount, with some capacity in reserve, six 66-in. by 18-ft. return-tubular boilers were installed. These were set in batteries of two and to obtain as large a unit as possible in the low headroom then available, a traveling stoker 9 ft. wide was provided for each battery. The boilers were set back against the wall, and the breeching was run overhead across the boiler fronts into the stack. The operating pressure was originally 125 lb., but in the 14 years since the installation of the plant it had been cut down to 100 lb. Although a stack 130 ft. high had been erected, the draft was poor because of the large quantities of cool air passing into the furnaces around the ends of the stokers or through numerous cracks in the settings. It was necessary to burn a high grade of coal to carry the load, and owing to air leakage and the loss between the two boilers the efficiency was considerably below the average. The installation was a good illustration of how the draft from a good stack could be "killed" by poor stoker arrangement. In 1901, however, the stoker was in its early development, so in all probability the engineers responsible for the work did the best they could under existing conditions, and with a headroom of only 12 ft. 9 in.

Last winter it was decided to improve conditions in the boiler room. It was known that the stokers were too large for the job and consequently inefficient, and as they were of a type that has been obsolete for a number of years, the repair bills were unusually high. It was at first thought that new stokers would be sufficient, but an investigation by W. L. Fergus & Co., consulting engineers, of Chicago, showed that an acceptable job could not be made with the boilers standing in their present condition. The boiler settings were nearly gone, and the shells of the boilers themselves did not have sufficient life remaining to wear out new stokers. For these reasons it was decided to install new boiler units complete. Two Heine water-tube boilers each of 2,500 sq.ft. heating surface, equipped with Detroit stokers having a projected area of 42 sq.ft., were selected.

During the change it was necessary to keep the plant in operation, and this proved to be a difficult piece of work. A battery of two boilers was removed and one

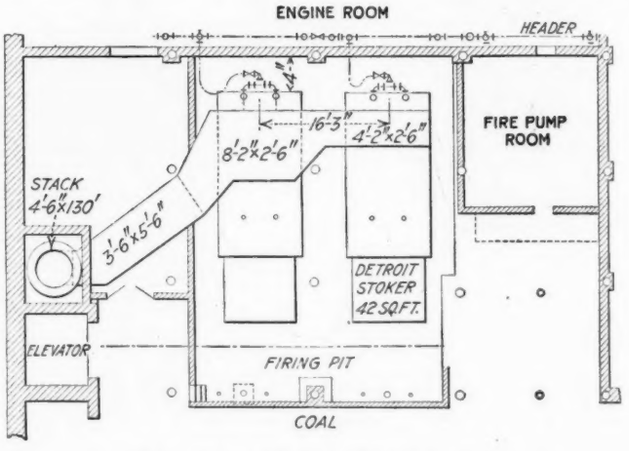



FIG. 1. PLAN OF NEW BOILER PLANT

of the new water-tube boilers installed. Instead of accepting conditions and making the best of it, as was the general practice in 1901, the headroom was increased considerably to allow proper space for the furnace. It was necessary to chip out the old ashpit walls for a depth of 3 ft., giving a headroom for the new boilers of 15 ft. at the rear and 15 ft. 6 in. at the furnace. Incidentally, the boilers had to be taken down into the boiler room in pieces and assembled on the job. The only available areaway into the boiler room was an elevator shaft measuring about 8 ft. square, so that even the boiler drums arrived at their final destination in three parts.

As soon as the first boiler had been properly installed and was ready to carry the load, two more of the old ones were removed, and at the present writing the second boiler is being erected under the same difficult conditions. While erecting the first boiler, it was necessary to provide a temporary breeching for the older ones and build a new breeching to the new boiler. This breeching will be extended to the second new boiler when it is ready for operation. At that time the two old boilers remaining will be removed and the space will be occupied by a fire pump.

It will be noticed in the upper view of Fig. 2 that the breeching flattens out over the boilers, but the sectional area of practically 20 sq.ft. is retained over the first

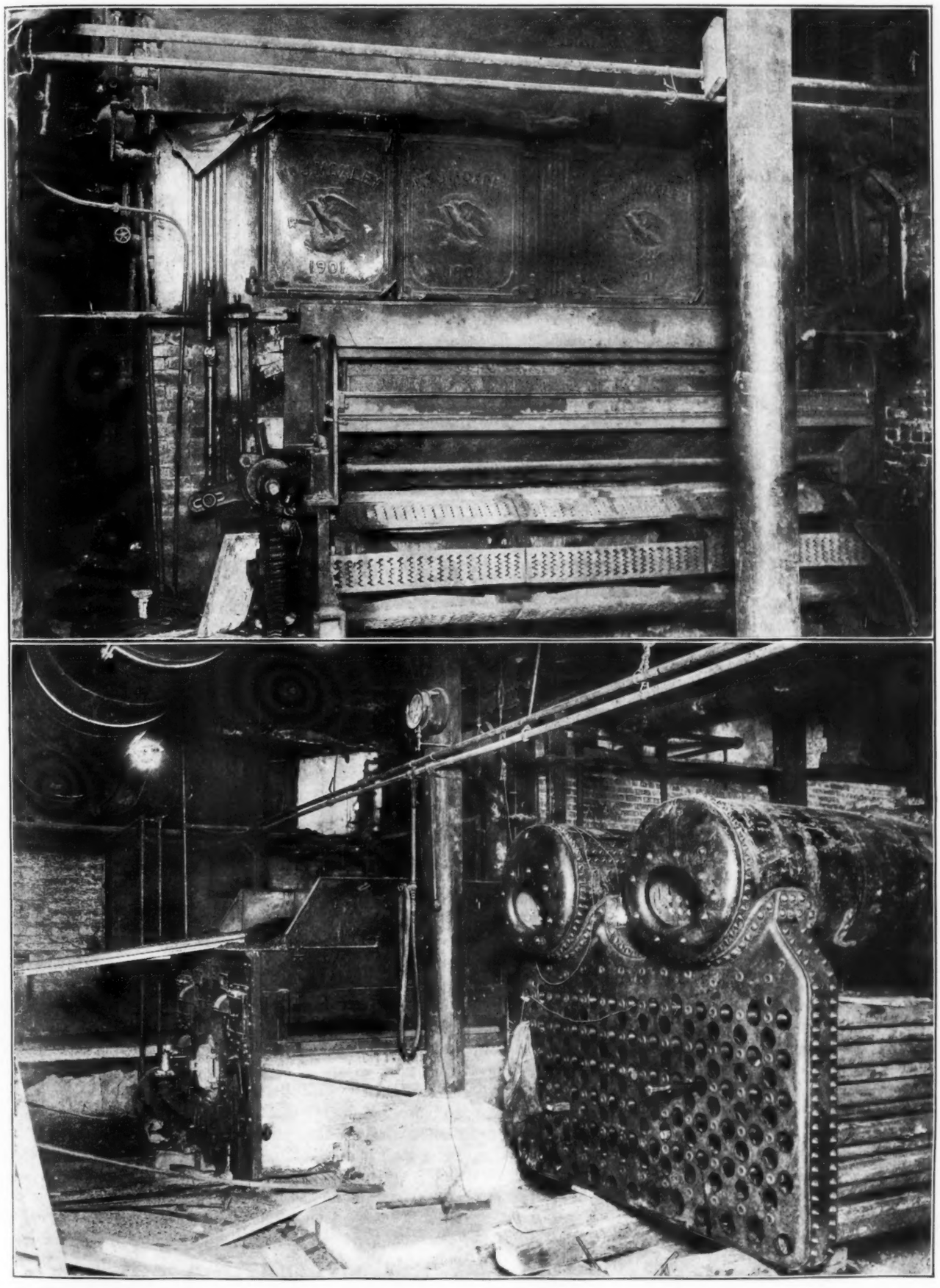


FIG. 2. UPPER VIEW—TWO OF THE OLD TUBULAR BOILERS SERVED BY ONE STOKER. LOWER VIEW—THE NEW WATER-TUBE BOILERS INSTALLED IN PIT

boiler and reduced by one-half over the second one. The stack diameter is 4½ ft. and the area 16 sq.ft. The breeching area, then, is 25 per cent. greater than that of the stack, and the connected grate surface per square foot of breeching is 4.2 sq.ft. At the present writing the first water-tube boiler has been in operation for a couple of months. The draft is more than ample, as the damper has been kept partly closed, and it will be better still when the last of the old boilers and the temporary breeching are removed.

The line drawing, Fig. 1, shows the layout as it will be when the installation is complete. Coal is stored in front of the furnaces at the level of the old floor line, so that there is only a slight inclination to the top of the stokers. It will be wheeled up the platform shown in Fig. 2, which is a view of the pit showing the two new boilers, one of which is just being erected. The ashes will be removed by a trolley hoist.

The new boilers are licensed to operate at 180 lb. pressure, although the one in service is carrying only 120 lb. As soon as the piping has been gone over, however, the pressure will be increased to 150 lb. to improve the efficiency of the compound engines. As there is no room to carry steam piping past the breeching, the steam is drawn from the back ends of the Heine boilers by means of dry pipes that extend to the front ends within the drums.

Although sufficient time has not elapsed to obtain reliable data on the new installation, it is known that the boiler-room economy has been considerably increased. Besides, cheaper coal can be burned efficiently. The two photographs, Fig. 2, illustrate admirably the change in boiler-room practice in the last fifteen years. The adverse conditions which were accepted in the original installation have been eliminated, uptodate equipment has been installed and a number of accessories in the way of instruments have been provided. Conditions were made right so that the boilers might be operated efficiently, and instruments were provided to indicate results and give the comparative data so necessary for improvement.

# Visits of Inspector Brown--XII

By J. E. Terman

*SYNOPSIS—Brown is sent to give advice regarding boiler setting, and the engineer and mason give him something to think about as to how the rollers under the side lugs should be placed. In the end Brown recommends suspending the boiler so as to avoid trouble from side and endwise movement.*

"Brown," said the Chief one day, "the tobacco factory on Henry Street wants an inspector to give them advice regarding the resetting of an old boiler. See if you can help them out."

When Brown reached the plant, he found the old boiler setting had been torn down and partly rebuilt, the mason having the new side walls finished up to the side lugs on the boiler. Upon Brown's arrival the brick mason and the engineer explained that there was an argument as to how the rollers should be placed under the rear lugs of the boiler. The boiler as originally set had wall plates under each lug and the rear lugs had 1-in. rollers between the wall plates and the bottom of the lugs, as illustrated in Fig. 1. The engineer wanted the rollers placed under the lugs in the same manner when the boiler was reset, but the brick mason wanted them placed lengthways of the shell, as shown in Fig. 2.

The mason claimed that in order to push a wall down it was necessary to push sideways on it, and that it could never be pushed down by pushing lengthways. He also claimed that the purpose of the rollers was to relieve the setting; therefore the rollers should be arranged his way, Fig. 2.

The engineer said that he never heard of placing the rollers under the lugs of a boiler in any position but his way, Fig. 1, and he appealed to Brown. Brown admitted that he had never seen rollers placed under the lugs of a boiler as advocated by the brick mason, but said that he was not so sure but that the mason might be correct in the matter.

"There is one thing," said Brown, "that I think we can all agree on. That is, rollers should be placed at right angles to the greatest movement between the wall and the boiler lugs. This boiler is 72 in. in diameter and 18 ft. long and the centers of the supporting lugs are about 10 ft. apart lengthways of the boiler shell. We want to calculate the greatest movement that can be expected to take place from the starting up of the boiler until steam is raised. Assume that the temperature of the boiler before starting was 70 deg. F. and that the average temperature of the shell after steam was raised would be 440 deg., which would be 80 deg. above the temperature of the steam due to its pressure of 140 lb., and which is a fair average increase over the temperature of the contents of a boiler to assume for the shell while steaming.

"With these assumptions, since the coefficient of expansion of iron per degree rise in temperature Fahrenheit is 0.00000648 and the rise in temperature from 70 deg. is 440 — 70, or 370 deg., then $0.00000648 \times 370 \times 10 \times 12 = 0.288$ in. would be the amount the 10 ft. of plate between the lugs would increase in length due to a temperature change of 370 deg. alone. Since the diameter of the boiler is 72 in., its increase in diameter due to a change in temperature of 370 deg. would be $0.00000648 \times 370 \times 72$, or 0.172 in."

"Hold on!" said the engineer, "not so fast! That boiler is not solid! How do you know that the increase per inch of diameter due to temperature change is the same as the increase per inch of length for the same change in temperature?"

"Why, this is the reason I made the calculation in that way, to save one multiplication and one division. If you should get the expansion in terms of the circumference it would then be necessary to transfer it back to diameter," explained Brown. "For example, $0.00000648 \times 370 \times 3.14 \times 72$ would represent the change in circumference due to the change in temperature, and in order to find what the change in diameter would be, the

result would have to be divided by 3.14, and since multiplying and dividing by the same number leaves the result unchanged, we merely leave the 3.14 out of the calculation. If you insist on seeing all the figures before your eyes, we will write it out this way:

$$\frac{0.00000648 \times 370 \times 3.14 \times 72}{3.14} = 0.172 \text{ in.}$$

"Since the pressure carried on this boiler is 140 lb. and the shell plate is $\frac{7}{16}$ in. thick, the stretch in the circumference due to pressure would be the stress per square inch times the length of the circumference times $\frac{1}{29,000,000}$, since 29,000,000 is the modulus of elasticity of steel plate. Writing this with the dimensions we have in this case," continued Brown, "we would have,

$$\frac{72 \times 140}{2 \times \frac{7}{16}} \times 72 \times 3.14 \times \frac{1}{29,000,000}$$

equal to the increase in circumference, and since we really want the increase in diameter, we will remove the 3.14 in the numerator as before, making the fraction read

$$\frac{72 \times 140 \times 72}{2 \times 0.4375 \times 29,000,000} = 0.0284 \text{ in.}$$

"This is a rather insignificant amount," said Brown, "but we will add it to our increase in diameter that was found to occur owing to the change in temperature and we get over 0.0284 + 0.172, or 0.20 in., so that the movement lengthways of the shell is 0.288 — 0.20, or 0.088 in. greater than it is across the diameter, and I guess that the engineer wins, 'Mr. Mason.' We will not consider the stretch of the shell lengthways due to the stress produced by the pressure in that direction, for I know from past experience in making such calculations that it would be insignificant."

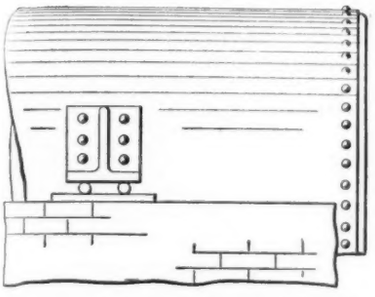


FIG. 1. HOW THE ENGINEER WANTED TO PLACE THE ROLLERS

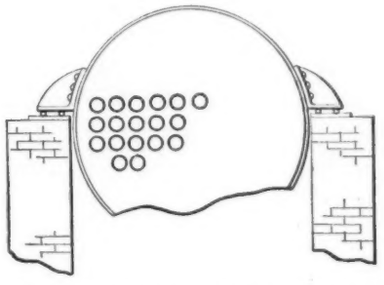


FIG. 2. BUT THE MASON CLAIMED THEY SHOULD BE PLACED THIS WAY

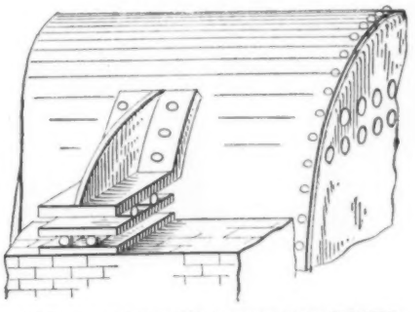


FIG. 3. AND THEN THE ENGINEER SUGGESTED THIS METHOD OF PLACING ROLLERS

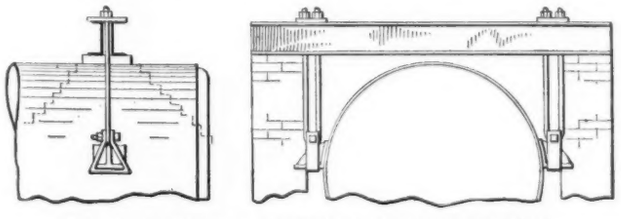


FIG. 4. BROWN'S METHOD OF SUSPENDING A RETURN-TUBULAR BOILER

"Well," said the mason, "according to your figures the engineer does seem to win, and I am unable to show that you are wrong, because I don't know a thing about the coefficient of expansion or modulus of elasticity that you have been talking about; but if you mean that you are figuring the stretch of the boiler endways to see how much those rollers move, you will have to come again to show me, for I can't see where you have taken into account the expansion of the brick wall on which the lugs rest, and it is just as necessary to consider this increase as that of the shell expansion in order to get the movement between the lugs and the wall."

Brown borrowed the engineer's handbook and found that the expansion of brickwork is a variable quantity, the coefficient of expansion varying from 0.00000256 to 0.00000494 per degree change in temperature Fahrenheit.

"Now," said Brown, "taking the least value for the coefficient of expansion and assuming that the part of the setting wall on which the boiler rests has an average temperature of 800 deg. F. when the boiler is in operation, we will have a rise in temperature of 730 deg., from a start of 70 deg. The 10 ft. of wall between the lugs would expand 0.00000256 × 10 × 12 × 730, or 0.224 in. By using the largest value for the coefficient of expansion the length of the brickwork between the lugs would increase 0.432 in., or an average expansion of 0.328 in.—just a little over $\frac{5}{16}$ in. The difference in the expansion between the brickwork and the shell under the assumed conditions would be 0.328 — 0.288, or 0.04 in., against 0.20 in. across the boiler, which we have already found.

"It looks to me, as if the mason had us both beat on this question," said Brown to the engineer. "I confess that I never thought of the matter in the same light before, but it stands to reason that the setting wall is much stronger to withstand a thrust endways than sideways, and for that matter the boiler is too, and if for any other reasons than these, I believe the mason is right in his idea of placing the rollers lengthways of the shell. The values we have assumed for the temperature of the brickwork and the shell are not exactly right, but they cannot be so very far wrong."

"Well," said the engineer, "it seems that only brick masons and boiler inspectors are blessed with brains in connection with this argument, but I notice that neither of you has said anything about the need for placing rollers under the front lugs of the boiler, and if the rear end puffs itself out so much, on account of the pressure and heat, as you have tried to make me believe, the front end must act in the same way. Now, what shall we do? Place rollers under both front and rear lugs like this," indicating Fig. 2, "or use two wall plates and arrange the rollers like this?" drawing Fig. 3.

"No, sir," said Brown, "don't be building any Chinese pagodas under those lugs, but place a strap around each

of them and use U-bolts to support the boiler from overhead channels carried on the setting walls. The proper way is to have columns set in the side walls to carry the supporting channels, but I know that there is no use in trying to have you use these now. The arrangement for hanging will be about like this," drawing Fig. 4. "Surely the boss won't kick on the little additional expense to make this equipment safe and prevent any need for calculating how much movement or stress there may be on those lugs."

"Well, I don't know," said the engineer, "just what he will say to the proposition, but I will tell him that it will probably keep his brick mason away from here longer than usual and that will bring him around, I know, for the boss would do anything to prevent him coming here again soon, and them are my sentiments, too."

# Fundamental Principles of Alternating Current--II

By F. A. Annett

*SYNOPSIS—In the Dec. 7 issue the author gave a simple explanation of the sine curve. The present article deals with the use of electrical degrees, the flow of an alternating current in a circuit and the relation between alternating and direct e.m.f. produced by the same machine. Effective e.m.f. in an alternating-current circuit will be considered in the next installment.*

The line *AO*, Fig. 9, is used to denote time, the period of time being expressed in degrees, minutes and seconds. It may at first be difficult to understand how time can be expressed in degrees, minutes and seconds instead of hours, minutes and seconds; but this is easily explained when it is considered that our 24-hr. day is the time required for the earth to complete one revolution (360 deg.) on its axis. When it has revolved through 15 deg., then $\frac{15}{360}$, or $\frac{1}{24}$ of a day (1 hr.), has passed. If the time required by the earth to make a revolution or part of a revolution can be expressed in degrees, it follows that the time required by any device to perform its cycle of operation may be expressed in degrees, minutes and seconds.

One should be careful not to confuse this with geographical or space degrees, although they are the same for a two-pole machine. In a four-pole machine the conductor would make only one-half revolution, that is revolve through 180 space degrees to pass by a North and one of its adjacent South poles, as shown in Fig. 10, where the conductor starts from the position *X* on the axis *AB* and revolves to the position *Y*. In doing so it has generated a cycle, as in Fig. 9; but in this case the conductor has passed through only 180 space degrees, although it has generated a complete cycle of 360 electrical or time degrees. On the other half of the revolution another cycle is generated, the curve in Fig. 11 indicating the complete series of values the e.m.f. passes through on a four-pole machine, which shows that the conductor in making one revolution (360 space degrees) generated 720 electrical or time degrees. In a six-pole machine the conductor would pass through 120 space degrees, or one-third of a revolution, in generating 360 electrical or time degrees; in an eight pole machine, 90 deg., etc.

The flow of an alternating current in a circuit is explained in Figs. 12, 13 and 14. Beginning at *A* on the time line, Fig. 12, the voltage starts from zero and increases in value until it reaches a maximum at 90 deg. Assume this gives the alternator a polarity as indicated in Fig. 13; then the increasing e.m.f. will set up an increasing current in the circuit of a direction as indicated by the arrowheads, and its value may be represented by the dotted curve, Fig. 12. Beyond the 90-deg. point the voltage decreases, becoming zero at the 180-deg. point; likewise, the current. At this point the conductor passes under a pole of opposite polarity and the e.m.f. is reversed. This will change the polarity of the machine as in Fig. 14, and again the e.m.f. and the current pass through a series of values from zero to maximum and from maximum to zero, in the opposite direction. From this it is seen that the current and voltage are continu-

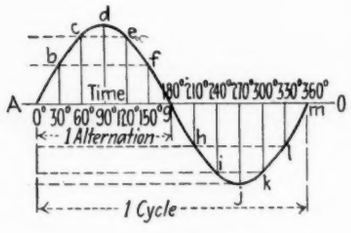


FIG. 9

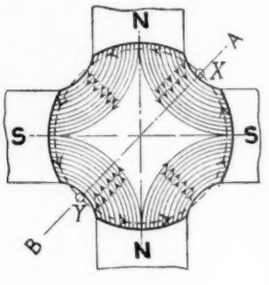


FIG. 10

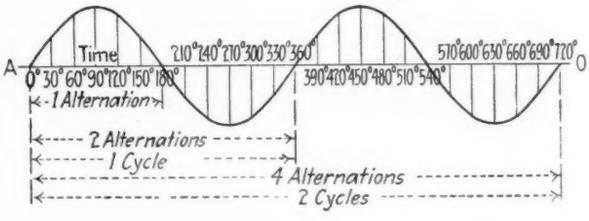


FIG. 11

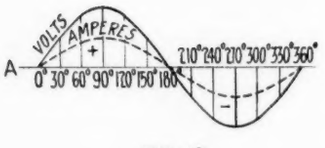


FIG. 12

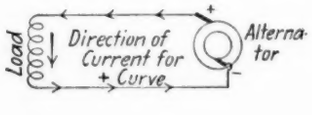


FIG. 13

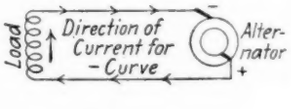


FIG. 14

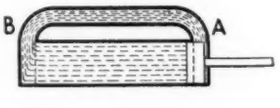


FIG. 15

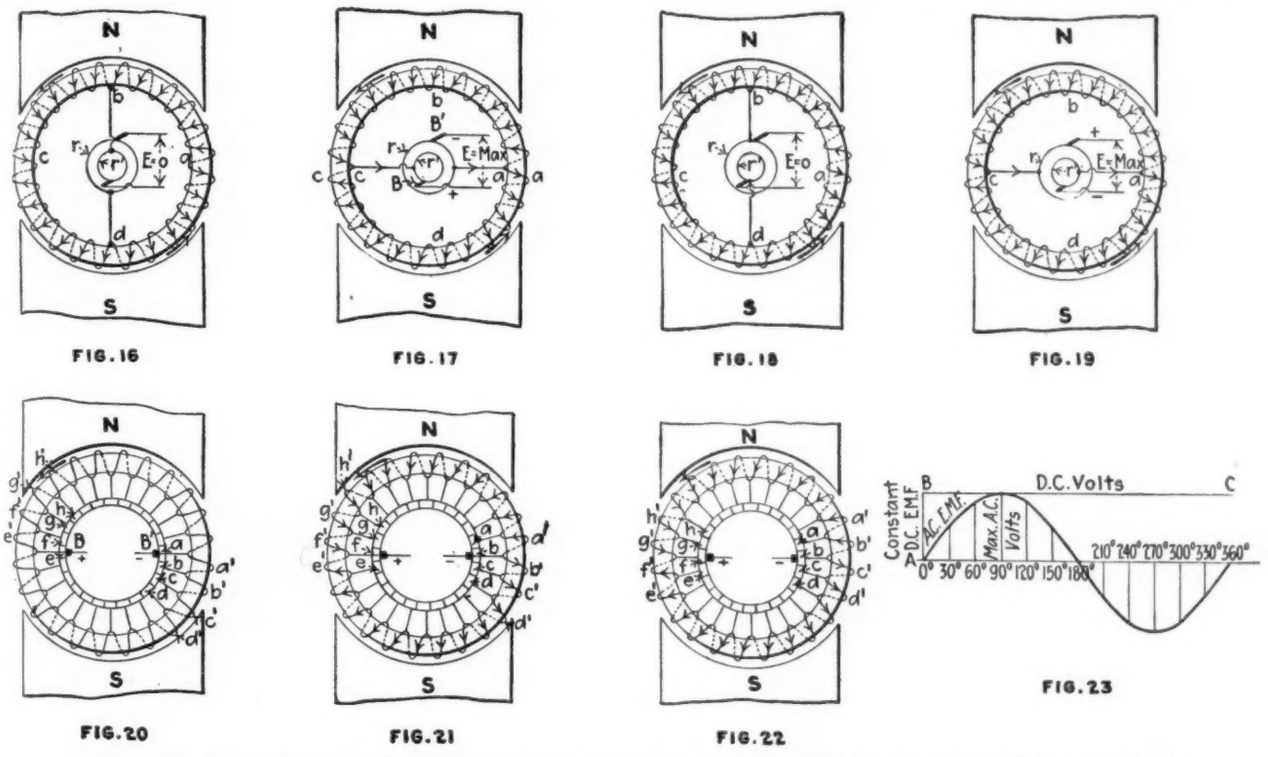
FIGS. 9 TO 15. ILLUSTRATING ELECTRICAL DEGREES AND THE FLOW OF ALTERNATING CURRENT

ally surging back and forth in the circuit; a wave in one direction being called an alternation, and a wave in one direction and then in the opposite direction, a cycle, or period, as shown in Fig. 9. An alternating current may be likened to the ebb and flow of the tide, the ebb being one alternation, the flow tide another alternation, the two combined forming a cycle.

Another analogy is shown in Fig. 15. Suppose the piston to start from rest at the position shown and gradually increase in motion and come to rest at the other end of the cylinder. This would cause the fluid to flow through the pipe from $B$ to $A$. If the piston reverses and returns to its original position, the fluid would flow in the opposite direction. Thus the fluid has completed a cycle, and if the piston is kept moving back and forth the water will be kept flowing back and forth in the system. This is the way a current of electricity flows back and forth in an alternating-current circuit.

What has been shown of the action of one conductor moving around in a magnetic field is also true of a number of conductors connected in series, as in Figs. 16 to 19. Here, for purposes of illustration, a ring armature is shown with several coils in series connected to two collector rings, $r$ and $r'$, the arrowheads indicating the direction of the e.m.f. induced in the armature conductors for the direction of rotation and the polarity shown. When in the position indicated in Fig. 16, the voltage between the collector rings will be zero, as the e.m.f. generated in the section $ab$ opposes that in section $ad$, likewise, the e.m.f. in section $bc$ opposes that in section $cd$. Consequently the e.m.f. between points $b$ and $c$ will be zero, and these are the points to which the collector rings are connected.

When the armature has moved around to the position shown in Fig. 17, the electromotive forces generated in the conductors are in the same direction on either side of the points where the rings connect to the winding; that is, the voltages generated in each conductor on either side of points $a$ and $c$ are in the same direction, and they combine to produce a maximum e.m.f. of a direction as shown. When the armature is in the position of Fig. 18, the e.m.f. will again be zero for the reason described in connection with Fig. 16. Hence, the e.m.f. at the collector rings starts from zero for the position shown in Fig. 16, increases to a maximum at the position in Fig. 17, then decreases to zero for Fig. 18; beyond which it increases until the armature is in the position of Fig. 19, where the voltage between the collector rings is again at a maximum, but in the opposite direction to that in Fig. 17, as indicated. When the armature completes the other quarter of its revolution, it will again be in the position shown in Fig. 16, and the voltage will be zero; consequently the e.m.f. has passed through the same series of values on the last half of the revolution as it did on the first half but in the opposite direction, just as that generated by the conductor in Fig. 8 (Part I).




FIGS. 16 TO 23. ILLUSTRATING THE DIFFERENCE BETWEEN ALTERNATING AND DIRECT CURRENT PRODUCED BY THE SAME MACHINE

Most modern alternating-current machines above 37.5 kv.-a. are constructed with the armature winding stationary and the field structure revolving and are known as revolving-field alternators.

At first thought it may seem that, since the voltage of the direct-current machine is constant and that of the alternating-current machine constantly changing, there must be some radical difference in the construction of the two machines. However, the only essential difference is that the direct-current machine requires a commutator, for changing the alternating e.m.f. generated in the armature coils into a direct e.m.f. at the brushes. How the commutator performs this function will be understood by referring to Figs. 20 to 22, which show the same combination of coils and polepieces as in Figs. 16 to 19, except

in the latter case the coils connect to a segmental commutator instead of two continuous rings.

The brushes $B$ and $B'$, Fig. 20, rest on segments $a$ and $e$, which connect to the points of maximum e.m.f., giving the external circuit the polarity indicated. As the armature continues to revolve, segments $a$ and $e$ move out from under the brushes and segments $b$ and $f$ move in, as in Fig. 21. This still leaves the brushes in contact with segments on the same axis as in the first case, which is also true in Fig. 22. From this it will be seen that the brushes are always in contact with a position in the armature coils of maximum voltage and constant polarity, which will deliver a continuous current in the external circuit, or, as it is usually called, a direct current.

It will be observed from the foregoing that the voltage of a direct-current machine having the same winding as a single-phase alternating-current machine will generate a constant voltage equal to the maximum e.m.f. of the alternating-current machine. This is indicated in Fig. 23, the curve representing the alternating voltage, whereas the vertical distance between the time line and the line $BC$ equals the direct-current voltage. Hence, it is apparent that a given armature winding will generate a smaller effective e.m.f. when connected to two slip rings than when connected to a commutator; in other words, the alternating e.m.f. will be less than the continuous e.m.f., the ratio being 0.707 to 1.

## Bolton Movable Bridge-Wall

An interesting development in engineering apparatus is the adjustable furnace for steam boilers, one of which has recently been put in operation at the Rhinelander Building, New York City. This furnace offers a simple means of adjusting the grate area to the fuel, the draft and the output of a steam boiler.

Where boilers are operated at variable rates of output or below their rated capacity, the adjustable furnace may

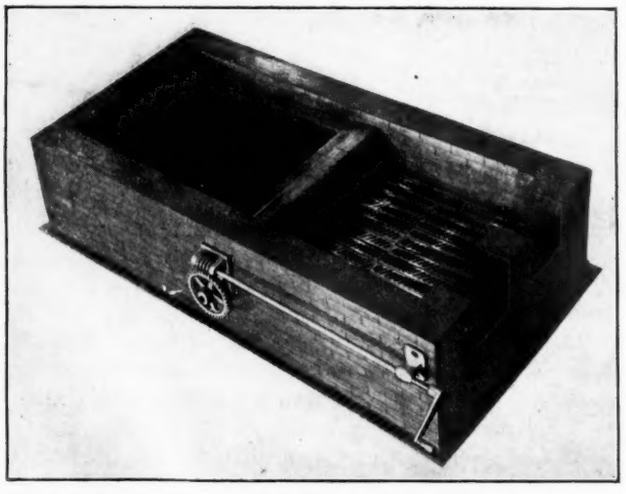


FIG. 1. MODEL OF MOVABLE BRIDGE-WALL

be used to proportion the grate so as to burn the fuel at the best rate per square foot of grate surface and thus maintain the most economical conditions for fuel combustion. For banking fires, the economy to be secured is readily apparent, since the coal may be banked on half the grate area. Fig. 1 is a view of a model.

The adjustable furnace consists of a movable bridge-wall, Fig. 2, of simple and substantial character. It may be handled by the fireman from the firing floor and can be adapted to any furnace to cover and expose any proportion of the grate area. Its special features include the means of cleaning off accumulations of ash and cinder as it is expanded or closed.

The movable part of the bridge-wall consists of a sliding frame filled with brick, which forms the same back to the fire as the ordinary fixed wall. It can be advanced

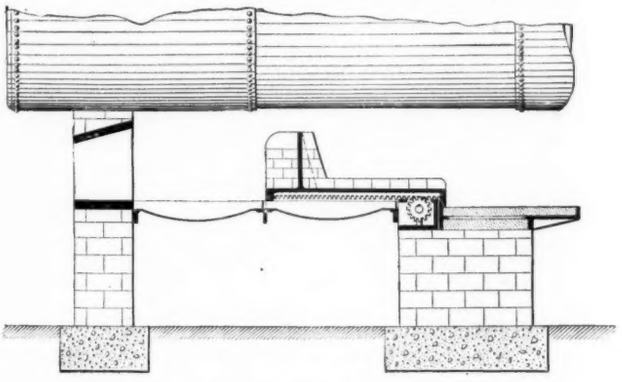


FIG. 2. DETAILS OF MOVABLE BRIDGE-WALL

forward over the grate by two racks and pinions. The sliding wall is mounted on a fixed plate secured to the brick bridge-wall, the upper part of which contains a tray filled with sand. Over this the upper, or movable, section can slide, its rear edge being formed like a scraper making contact with the sand. By this means a joint is made between the sliding and fixed parts in any position in which the wall may be placed. The joint thus prevents the passage of air through the unused portion of the grate.

The upper, or sliding, wall is advanced or retired by two heavy racks secured under the framing. These are geared to pinions mounted on a cross-shaft extending through the side wall to a worm gear. The rear part of the upper, or sliding, wall is formed as a tray, which is filled with sand, thus protecting the metal parts.

It can be fitted to any boiler without other change than the removal of the top of the fixed bridge-wall. It is made in sections so that it can be passed through the ashpit doors. No change is required in the grate, whether it be fixed, shaking or dumping. There are few moving parts. The worm and gear-wheel which move the bridge-wall are on the outside of the boiler setting and the wall is moved by turning a crank in the fireroom.

This appliance is manufactured by the New York Service Co., 320 Broadway, New York City.

**Copper Alloy Mixing and Melting** was the subject of a paper recently presented before the British Foundrymen's Association. The results of tests indicated that, in the case of brass, increase in zinc added elongation to the copper until the proportion of zinc incorporated reached 30 per cent. and the tensile strength continued to increase until the proportion of zinc amounted to 45 per cent. After these limits were reached in either case, there was a rapid fall. Curves of the tensile strength and elongation crossed when the zinc content amounted to 40 per cent.; hence 60 per cent. copper and 40 per cent. zinc was the universal mixture for cast brass, but since the elongation was the greatest when the zinc content reached 30 per cent., a mixture consisting of 70 per cent. copper and 30 per cent. zinc was found to be best for drawing tubes and rolling into sheets.

**Pure Mineral Oils** do not contain fatty acids, so that even a trace of acid is pretty conclusive evidence of a compounded oil.

# Some Recent Experiments in Surface Combustion--II

By L. J. Bradford* and C. D. Corwin*

*SYNOPSIS—Second of two articles dealing with surface combustion. The first was a brief summary of the available literature on the subject and this one describes the apparatus used in experiments by the authors and gives their conclusions on the application of surface combustion to steam boilers.*

The investigation described herewith was prompted largely by the writings of W. A. Bone, which were referred to in the first article. It was not intended to be an exhaustive study of the application of surface combustion to the production of steam, but preliminary to a more complete investigation. Writers on the subject have made but slight mention of difficulties encountered in making use of surface combustion, and these must be known before any apparatus can be designed for thorough study. The apparatus used by us was designed to bring out the general features of the problem, to be inexpensive and easily altered.

A single-tube boiler, Fig. 4, made up of a 6-in. pipe 6 ft. 6 in. long and having a standard flange screwed to each end was used. To each of the flanges was bolted a cast-iron plate having a hole in the center large enough to slip over a 3-in. pipe, which acted as the tube. The stuffing-boxes shown in Fig. 5 were provided at each end of the pipe to take care of expansion. A baffle 3 ft. long made of light galvanized iron shaped as shown in Fig. 6 was placed inside the boiler below the tube to assist circulation, the lower end of the baffle being about 10 in. from the fire head of the boiler. The boiler was inclined so as to give a rise of 18 in. in 6 ft. Water was supplied from the city mains through a ½-in. pipe entering the experimental boiler about 4 in. from the fire head.

Trouble from priming was anticipated, and to care for it a special separator, Fig. 7, was made. Steam was taken off by a ½-in. pipe connected about 4 in. from the waste gas head. This pipe led into a separating chamber, at the top of which was attached the steam gage and a ¾-in. pipe leading to the condenser and calorimeter, while the bottom was attached to the pipe supplying the water. Steam and water coming from the boiler were separated in the tee; the water returning to the boiler by means of the feed pipe, while the steam went to the condenser and calorimeter. The water column was also attached to the separator. The separator, feed pipe and boiler, with the exception of the heads, were lagged with asbestos cement applied over a ¾-in. air space.

Within the lower end of the tube was placed a cylindrical fireclay nozzle 6 in. long, containing four ⅜-in. holes through which the mixture of gas and air was supplied. The tube was packed with pieces of firebrick ½ to ¾ in. diameter for a distance of 4 ft. from the end of the nozzle, the remainder of the tube being empty. The mixture of gas and air was supplied to the nozzle through a ¾-in. pipe attached to a 3-in. cap fitting over the lower end of the pipe. This cap also served to keep the nozzle closely against the broken firebrick.

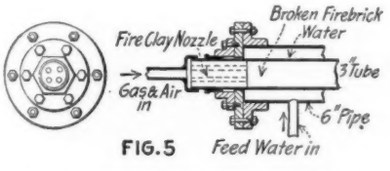



FIG. 5. STUFFING-BOX SECTION

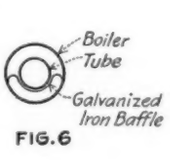



FIG. 6. BAFFLE

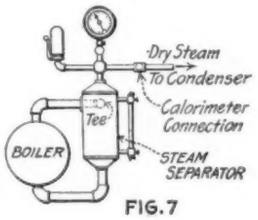



FIG. 7. STEAM CONNECTIONS

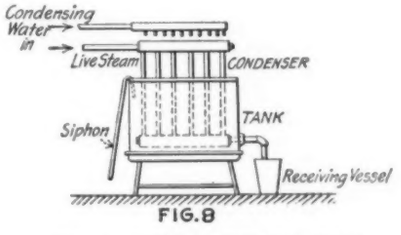



FIG. 8. THE EXPERIMENTAL CONDENSER

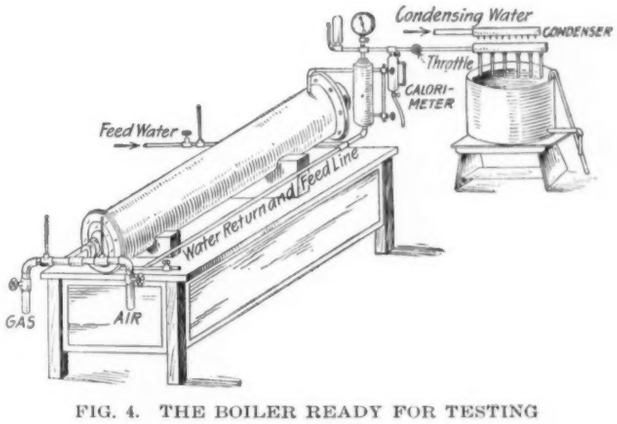



FIG. 4. THE BOILER READY FOR TESTING

A surface condenser (Fig. 8) was used, consisting of six 1¼-in. pipes connected in parallel to two 1¼-in. headers. The lower header and about half the length of the tubes were immersed in a barrel filled with cold water which was kept continually trickling over the upper header and upper half of the pipes.

Air and gas were brought to the desired pressure separately by means of a pair of Root No. 3 rotary pressure blowers. From the blowers the gas and air passed through separate receivers to the gas and air meters. The pressure on the gas and air was measured by means of mercury manometers attached to the supply pipes at points a few inches from where these entered the meters. All instruments used in connection with the work had been calibrated previously by standard methods.

*Instructors in machine design, Sibley College, Cornell University.

From the meters the gas and air each passed through a throttle valve and thence to a tee, where they were combined, and the mixture passed directly to the nozzle. The temperatures of the gas and air were taken just before they entered the mixing tee. The proportions were controlled by adjustment of the throttles. (See Fig. 4.)

Before the apparatus was evolved a number of other arrangements were tried. The boiler was originally horizontal. Two rather serious difficulties were met with it in this position. First, owing to the small steam space possible and to the high rate of evaporation in the region of combustion, the boiler primed so badly that it was found impossible to separate the water from the steam. Secondly, the firebrick could not be packed uniformly in the tube, an open space being left at the top, though the brick packed closely at the bottom. Inclining the boiler was found to improve both conditions, and probably the best results could be obtained from a vertical boiler.

### Method of Conducting the Tests

The fire was started by first turning on the gas and lighting it at the end of the tube. No air was supplied at this time, and the gas burned outside the tube with a yellow flame. Air was then gradually admitted, and as the amount was increased the color of the flame changed from yellow to blue, and soon there was formed at the end of the tube a distinct greenish cone resembling the inner cone of a bunsen burner. After this condition was reached a slight increase of air (making the ratio of air to gas 5 to 1) caused the flame to travel down the tube and become concentrated just outside the nozzle. The adjacent pieces of firebrick were soon heated to incandescence and surface combustion established. Among the several difficulties encountered in starting the fire were the following: When the apparatus was cold the flame would strike back violently and be extinguished, either by the shock of the explosion or by the chilling action of the firebrick and tube walls. Sharp explosions also had the peculiar effect of driving the nozzle forward. As far as could be ascertained by appearances of nozzle and mixing chamber, no explosion occurred behind the nozzle, although the sharp explosions drove it forward, pushing the firebrick ahead of it. No satisfactory explanation of this action can be offered at present. It was also found that when a space of more than ½ in. was left in the tube behind the nozzle, these explosions rendered it difficult to start or to maintain a fire. No explanation for this behavior can be offered. When, however, the nozzle was so placed as to have ¼ in. between it and the back face of the mixing chamber, only slight difficulty was experienced in starting and none at all in running.

### Combustion Noisy at Start

When first started, that is to say before surface combustion was established, the flame was quite noisy. This was due to the vibrations of the flame; such vibrations being amplified by the tube, which acted as a resonator. As the firebrick in front of the nozzle became heated, the sound decreased and finally ceased. When proper conditions of mixture were obtainable, the only sound was that made by the passage of the gases over the refractory material. The ceasing of the sound may be accounted for by the fact that surface combustion is flameless, hence when this stage was reached the flame disappeared. Its gradual disappearance is accounted for by the fact that a short time was necessary for the firebrick in front of the nozzle to become heated sufficiently to cause surface combustion. The surface of these pieces of brick was not large enough to cause all the gas to burn. Part of the mixture burned flamelessly and part did not. Hence it will be readily seen that the gradual decrease in the size of the flame caused a simultaneous diminution of the noise.

### Rapid Combustion Causes Priming

In preliminary runs considerable difficulty was experienced from priming of the boiler. In surface combustion all the gas is burned within a few inches after leaving the end of the nozzle. This rapid combustion, together with the small excess of air, is productive of very high temperatures and consequently high rates of heat transfer through that portion of the tube surrounding the zone of combustion. This caused a large bubble of steam to form, which forced the water lying above it in the boiler up into the steam space and pipes. This trouble was found to decrease as the inclination of the boiler was increased.

Once the fire was started, the gas throttle was adjusted until the desired amount of gas was being burned, then the air throttle was adjusted until 5¼ volumes of air were being supplied for each volume of gas. This was found by flue-gas analysis to give but a slight amount of free oxygen in the waste gases. Steam pressure was allowed to build up to the desired amount, and then the throttle valve was opened and sufficient steam to keep the pressure constant was allowed to flow into the condenser. As soon as conditions became steady the quality of the steam was determined by the use of a separating calorimeter. After this had been done a flying start was taken on the test proper. A vessel that had been previously weighed was placed under the pipe leading from the condenser, and the time noted.

The quantity of gas and air used was found by taking with a stop-watch the time required for the meters to register one cubic foot. The temperature and pressure of each were also noted, the pressures being obtained by mercury manometers. From these data the actual quantities of gas and air under standard conditions used during the run were easily calculated. From time to time water was fed into the boiler, the object being to keep the water level constant. The temperature of this feed was taken, as was also that of the waste gases, calibrated mercury thermometers being used in all cases. At the end of the run the vessel receiving the condensed steam was removed and weighed. The difference between the final weight and that of the vessel gave the weight of water evaporated.

### Little Excess Air Used

All the tests were conducted in the same manner, the only difference being the quantity of gas burned per hour. In all the tests slight leakage occurred through the stuffing-boxes and around the steam connections. A sample of the flue gas was taken during each run and an analysis made of it, using the Orsat apparatus. These analyses showed that practically complete combustion had been obtained with small excesses of air.

In one of the preliminary tests a pyrometer was placed in the tube, and the temperatures at the end of the tube

and at the end of the firebrick were measured. In this case the tube was filled with brick 3 ft. from the nozzle, and about 90 cu.ft. was burned per hour. The temperature at the waste-gas end of the tube was 280 deg. F.; that just outside the firebrick, only 320 deg. F.; showing that at that rate of combustion the last three feet of the tube were practically useless.

The maximum amount of gas burned per hour was 125 cu.ft. at 60 deg. F., and 29.92 in. mercury. At this rate the boiler performed satisfactorily in all particulars. Higher rates of combustion were not employed, because it was found impossible to obtain more gas from the ½-in. supply pipe.

### Conclusions Drawn from the Experiments

As a result of the work described in the foregoing, the following conclusions are drawn:

High efficiencies are attainable. In the tests made by Bone the radiation and leakage were reduced to 2 per cent. and an economizer was used. He obtained an efficiency of 94.3 per cent. In the tests herein described the radiation and leakage amounted to an average of about 11 per cent. and no economizer was used. Even with these defects of apparatus an efficiency of between 75 and 80 per cent. was obtained. Assuming other things to have remained constant and the radiation to have been reduced to 2 per cent., the efficiencies would have ranged from 84 to 89 per cent. No economizer was used, so the agreement with Bone's results is close. The large radiation and leakage loss was due to the stuffing-boxes, through which leakage occurred and whose presence compelled leaving the ends unlagged. Another reason for the large radiation loss lies in the fact that but one tube was used. Radiation takes place from the surface of the boiler shell. This increases much less rapidly than the heating surface when additional tubes are introduced and the size of the boiler increased. The apparatus used was therefore operating under most unfavorable conditions and yet gave good efficiencies.

The efficiency varied with the rate of combustion, increasing with the amount of gas burned per hour. Stack conditions are probably truer indices of the efficiency of the apparatus as an absorber of heat than is the ratio of the heat in the condensed steam to the heat supplied. The latter charges the radiation, as well as losses in combustion and transfer, against the boiler. The efficiency based on the heat in the steam is therefore a measure of the boiler's ability to hold as well as to absorb heat. In this investigation the object was to determine the value of surface combustion as a means of getting heat out of the fuel and into the boiler. This is shown clearly by the temperature difference between the flue gases and the steam. This difference was found to increase with the rate of combustion, but not rapidly, the maximum difference being only 74 deg. F. The sensible heat lost in the waste gases was therefore small, varying from 3½ to 4 per cent.

The main loss in the flue gases occurs as latent heat in the water vapor formed by the combustion of the hydrogen in the fuel. From this it will be seen that surface combustion will be most efficient when using a gas low in hydrogen, such as producer gas made from anthracite. Blast-furnace gas would give good results were it not for the large amount of inert gas present. A curve (not shown) shows that the water evaporated per hour when the rate of combustion was 125 cu.ft. per hr. was less than the general direction of the curve would lead one to expect. This was because the mixture entering the nozzle contained a larger excess of air than did the mixtures used in the other tests. It brings out clearly the deleterious effect of an excess of air, even though that excess is small. The efficiency was not computed for this run, because the heating value of the gas was not available.

### Range of Combustion Rates

The system is a flexible one. No difficulties were experienced while burning either large or small quantities of gas, and the change from one rate of combustion to another was accomplished almost instantaneously. This feature makes the system particularly desirable where the load is extremely variable.

The amount of gas that can be burned per unit of time seems to be limited only by the supply and by the ability of the refractory used to withstand the high temperatures. Combustion seems to be as good at high as it low rates. A large part of the transfer of heat from burning gases to the water is affected by radiation from the incandescent refractory material within the tube.

The rate of heat transfer by means of radiation varies directly as the fourth power of the absolute temperature, so an increase in the temperature of the radiating body is accompanied by a rapid increase in the amount of heat transferred by radiation. Since the temperatures within the tube increase with the rate of combustion, it follows that the heat transferred by radiation will increase. In the ordinary boiler a great loss in heat transfer occurs in getting the heat through a thin film of stagnant gas adhering to the surface of the boiler shell or tubes. Since this film is practically stagnant, little or no heat is passed through it by convection.

The gas offers practically no resistance to radiant heat so the capacity of the heating surface will be increased by increasing the proportion of radiant heat liberated from the fuel.

It was found that the furnace, once started, gave no trouble provided no large space existed directly behind the nozzle. When such a condition did exist, combustion became unsteady and rather sharp explosions occurred, which drove the nozzle and firebrick forward. This difficulty was greatest when starting, it frequently being impossible to get a fire established until the nozzle was pulled back and the space back of it made quite small. Some difficulty was experienced in starting, even when the nozzle was in the correct position, because of chilling of the flame by the cold walls of the tube.

The main difficulty found with the apparatus was priming. There should therefore be considerable steam space above the surface of the water, and circulation should be as direct as possible.

### Large Steam Space Recommended

The foregoing work indicates that the vertical type of boiler would probably give the best results, as the space available above the water can be made as large as desirable and the circulation is rapid. The boiler should not be over 4 ft. in length and probably 3 ft. would be satisfactory, as observations made of the temperature inside the tube show that there is only a small drop in temperature in the last 3 ft. of a 6-ft. boiler.

The application of surface combustion to the production of steam for power seems feasible. The small size and consequent small cost of the boilers would result in a saving in space and a reduction in fixed charges. These advantages would largely or entirely be offset if gas producers were necessary, but for natural or blast-furnace gas the system appears to be almost ideal, and in localities where coal is poor in quality it combines the reliability of the steam engine with the economy of the gas engine.

## States Sectional Grate Bar

The States sectional grate bar (patent pending) has been designed with several features that will appeal to engineers using hand-fired furnaces. The general appearance of the sections is shown in Fig. 1. One of the features is that all of the grate area is active because the sections are made with 3/8-in. air spaces from end to end and so arranged that 51¼ per cent. of the grate

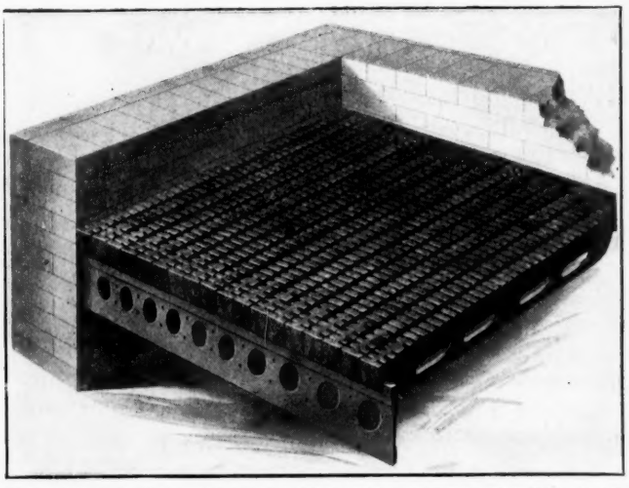


FIG. 1. GENERAL APPEARANCE OF STATES GRATE BARS

is air space, which extends both lengthwise and crosswise.

A side view in section is shown in Fig. 2. The stools are reinforced between each pair, and each air space is constructed with a taper, giving a venturi effect to the entering air. This taper construction also allows any particles of ashes that pass through the top opening of the air spaces to fall into the ashpit. Fig. 3 shows an end view of a grate section. Fig. 4 is a top view of a

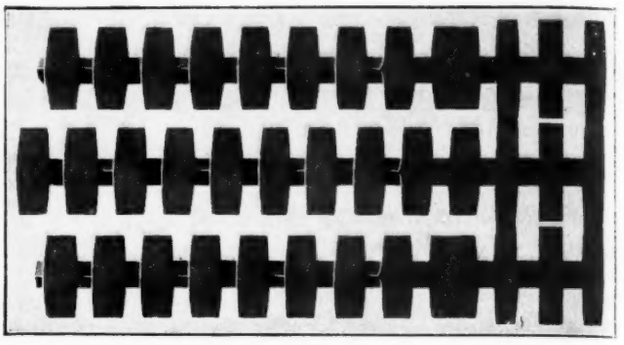


FIG. 4. TOP VIEW OF BAR SHOWING STAGGERED STOOLS

section, showing the staggered construction of the stools. This is to prevent loss of fuel through the grates, and it incidentally prevents the firing tools from catching. The stools, the only parts of the grate that come in contact with the fire, are cooled by air circulating past them on

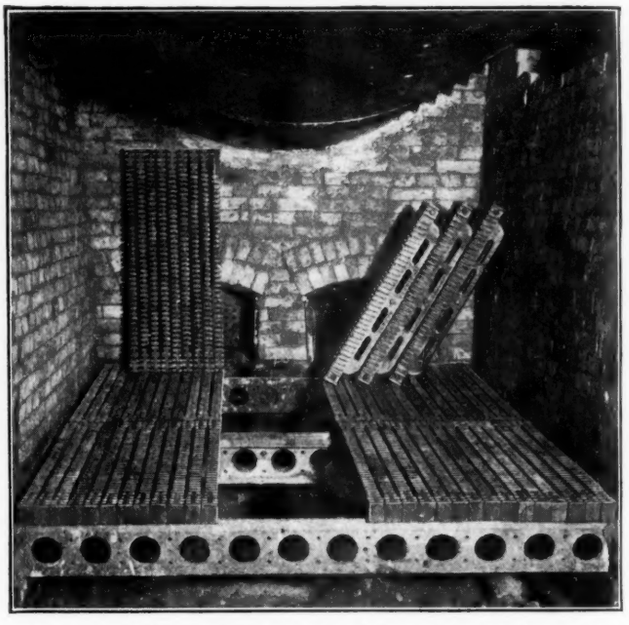


FIG. 5. FURNACE WITH TWO LENGTHS OF GRATE BARS

four sides. The largest dead surface in any section is the fuel-supporting area of each stool, which is less than ¾ to 1 sq.in. area.

The bars of each section are held together as shown in Fig. 3. This permits of removing any one bar for renewal, which feature reduces the repair cost. All parts

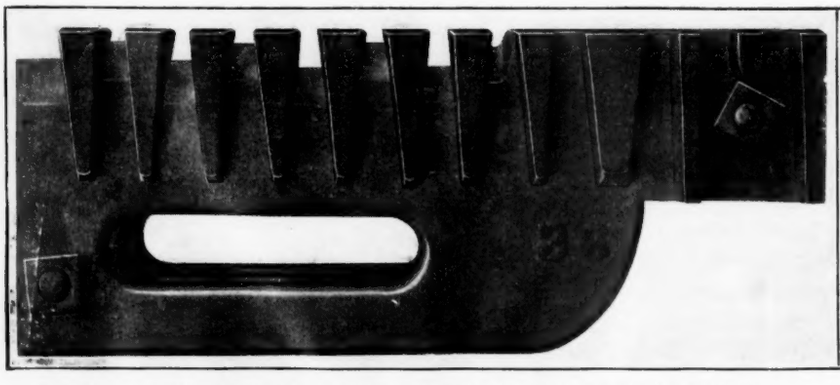


FIG. 2. SIDE VIEW OF GRATE BAR SHOWING REINFORCEMENT BETWEEN THE STOOLS

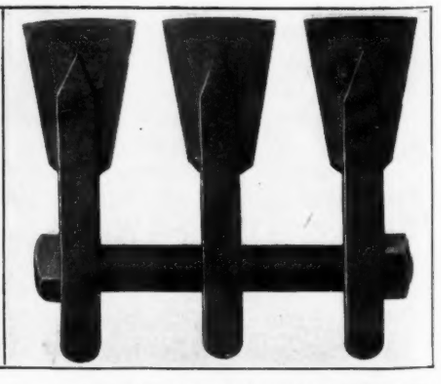


FIG. 3. END VIEW SHOWING BEVELED REINFORCEMENTS

are interchangeable, and any bar will fit in any section. If the spacing does not stagger, the bar is turned end for end. If the furnace is long, two sections are placed end to end, as shown in Fig. 5.

As the grates are made up of sections the width of which is but 2 in., any width of furnace can be fitted without special parts by using more or less than three sections in the grate to fill in next to the wall, when the furnace width is not a multiple of the grate width of 6 in.

The grate is made by the Eureka Manufacturing Co., Lincolnton, N. C.

# Notes on Overhauling the Refrigeration Plant--III*

By F. E. Matthews

*SYNOPSIS—Methods of removing moisture from insulation and of repairing and securing the latter are described.*

If refrigeration is being lost by convection through the leakage of air through cracks, around doors or windows, the remedy will suggest itself. Slight currents can be detected easily by smoke judiciously applied. When there is a general leakage of cold, not by convection but by transmission through all the surface of the refrigerator, the remedy is less simple and will be different under different conditions.

If any part of the surface seems colder than others, it would be advisable to explore beneath it with a small bit. If this is carefully done and the distance the bit has traveled before striking each different layer of material is closely measured, valuable information regarding the construction of the walls will be had. If the borings indicate that the various materials are damp, it will be evident that the efficiency of the insulation cannot be high. If the materials are not rotten and the total wall thickness not too great, it may be possible to improve the efficiency by drying. Such a treatment will require considerable time and put the refrigerator out of service while the work is going on.

### Making Wet Insulation Dry

Moisture on the interior of the insulation must be induced to come to the surface. This it will do slowly by capillarity. Unfortunately, that force is strongest in that part of the wall, all other things being equal, where the temperature is lowest. Then not to have capillarity exerted in the direction opposite to that where the heat is applied, sufficient time must be allowed to heat not only the surface, but the whole thickness of the wall, and then to allow the moisture to be drawn out by capillarity operating between the damp interior and the dry surface. If heat can be applied to both sides of the wall, the time required for drying will obviously be reduced. Heat having been provided to allow the water to evaporate, the necessity of disposing of the saturated air and the introduction of fresh air, with its water absorbing affinity not satisfied, must not be overlooked.

Whether the application of heat to the interior of a refrigerator wall will or will not be effective in removing the moisture depends largely on whether there is or is not an effective waterproofing layer near the outside surface. When heat is applied to the inside the surface is dried, and if the insulation lying immediately under is wet there will be some tendency for that moisture to be brought to the surface by capillarity. Insulation, even while damp, is a poor conductor of heat, and unless the heat is applied long enough to allow the wall to become heated through, it will give rise to differences in temperature which will tend to draw the moisture toward the strata of lowest temperature, or away from the inside surface. If it encounters a waterproofing layer as it nears the outside of the wall, it is obvious that it will be unable to escape.

If there is no waterproofing course on the inside, the logical method to employ would be to apply heat to the outside, cold to the inside, or, since both act in the same direction, heat outside and cold inside simultaneously. Capillarity working in the direction of the lowest temperature will then draw the moisture away from the waterproofing course in the direction of the side where it can find easy exit. If the waterproofing course is near the inside, heat should be applied to the inside, preferably at such times as the temperatures are lowest on the outside.

The use of cold in drying has marked advantages over that of heat. With heat it is necessary to change the air as soon as it becomes saturated, while with cold, where direct expansion or brine piping is usually employed, the same air is dried by contact with the much colder surfaces of the refrigerating pipes, the moisture being deposited in the form of frost. The process of drying by cold would be hastened by the supplying of the latent heat of vaporization of the water from the outside or, more accurately, from the opposite side from that on which the cold is applied. Heat fortunately has the advantage, not possessed by the moisture, of being able to pass through the waterproofing courses. This permits of applying it on the waterproofed side where cold; inducing capillarity in its direction would not be effective. If there is a waterproofing course on both sides, there will be little possibility of the insulation becoming damp so long as these courses remain effective. If insulation is found to be damp, it is sufficient proof of its ineffectiveness.

### Removing Ice from Insulation

Notwithstanding that the brine and ammonia are colder than the rooms that they cool, the insulation of these pipes is rarely as efficient as that of the cooler walls. Because the medium is colder, the insulation should be better; in fact, if of the same material as that on the walls, it should be thicker in the same ratio as the difference in temperature between the brine or ammonia and the outside air is greater than that between the air inside and outside of the refrigerator.

*For articles I and II see "Power," Oct. 26 and Nov. 2, 1915.

When brine- or ammonia-pipe insulation has begun to break down and is full of ice, it should be replaced. The ice can be removed effectively only by disconnecting the pipes and turning steam into the line until the ice is melted. If it is thought desirable to repair rather than replace the old covering, the steam should be left on the line until the insulation has become dry, after which it should be again waterproofed, covered with an additional layer of canvas, or possibly additional insulation and then canvas, and again waterproofed.

From the standpoint of resistance to moisture the waterproofing layer of cold-storage insulation is always best on the outside. No excuse can apparently be found for the common practice of applying a waterproof layer of canvas, as is frequently done where hair felt is used next to the pipe. This does not apply to the waterproof cements used for securing sectional coverings to the surface of the pipe. Their function is different, for aside from securing the covering they serve to fill the spaces between pipe and covering, doing away with the destructive "dead air" space so much sought a few years ago.

Lack of care in selecting materials for, and in the construction of, insulation is sometimes explained on the grounds that the refrigerator temperatures are high and the difference in temperature between the inside and the outside air is slight. When saturated air comes in contact with a cold surface, precipitation of moisture is inevitable no matter how slight the temperature difference. The amount of moisture deposited when the dew point is reached is limited by the heat transmission through the insulation, for before a given quantity of moisture can be precipitated a definite amount of heat must be extracted.

### Proper Thickness of Insulation

If the insulation to be repaired is dry or can be made dry, it should be made thoroughly waterproof before the cold is again "turned on." If the insulation is dry or can be made dry but is too thin or is constructed of too poor insulating material, it can be advantageously reinforced with a 1-, 1½-, 2- or 3-in. course of sheet cork or other less efficient insulating material. In deciding on the thickness of the additional layer to be applied, it should be remembered that the cost for labor and material for applying and finishing will be the same regardless of thickness. The cork-insulation manufacturers also make an additional charge for the 1-in. and the 1½-in. thicknesses. It is questionable whether it ever pays to use less than 2-in. thicknesses of sheet cork either in the repairing of old or the constructing of new insulation.

As for the arrangement of the various insulating materials in built-up insulation or the order in which the heat encounters them in passing from the warm to the cold side, there seems to be little ground for the belief that it makes any difference. From the viewpoint of making the insulation resistant to moisture, there is an important difference. The most waterproof materials should be placed on the side where the cold surface of the insulation is in contact with warmer, moisture-laden air. In case of cold-pipe insulation this will be the outside only and with refrigerator walls will be the outside most of the time; but since cold air, being heavier than light, goes out whenever the door is opened, and an equal volume of warm moisture-laden air rushes in at the top, it follows that the inside surfaces of the insulation, particularly those of the ceilings, should be able to withstand the moisture precipitated there.

If the inside surface of the insulation which is to be increased in efficiency will allow of portland cement being used, use it. If not, the sheets may be dipped in hot asphalt and additionally secured by nailing if the surface permits. If cork sheets are used the surface can be finished with portland-cement plaster.

### Insulating Materials Used Today

The tendency of the best insulation practice for the past fifteen years has been toward the use of solid, nonhygroscopic materials of low heat conductivity, which can be secured to the walls, floors and ceilings of refrigerators by strong cementing substances such as pitch, asphalt and portland cement, without the use of metallic bonds. No wood falls in this class. No one who has encountered the annoyance caused by the sticking of a desk drawer every time there is a slight change in atmospheric humidity can be convinced that wood is not very hygroscopic even when protected as well as possible from the outside air by means of fillers and varnishes.

Insulating papers when new are fairly waterproof; those coated and saturated with asphalt should be permanently so. Others, saturated with mineral oils and tars of such a nature as to be absorbed into the adjacent wood with which they are in contact or capable of drying out by simple evaporation, should never be used. Even where the best of paper is employed it is not always so arranged as to offer the most protection to the insulating materials. Paper is usually applied between successive layers of wood, little attention being paid to the covering, or otherwise waterproofing, of the ends of the wood, through which water is most likely to enter by capillarity.

The insulating materials commonly employed are pure and impregnated sheet cork, mineral-wool slabs and sheets of compressed vegetable fiber. Of these sheet cork alone possesses the advantage of having air cells of microscopic dimensions. This material is also moisture-resistant and for usual conditions requires no other waterproofing than that afforded by the cement, asphaltic or portland, in which it is erected and finished. This material also has sufficient structural strength to allow it to be secured in place by nailing, although that method is to be discouraged.

Where a second layer of cork is to be added to the one secured by nails and it is to be erected in portland cement, one nail per square foot is sufficient to amply secure the first course to the side walls. Two nails per square foot should be used in securing the first course to wooden ceilings. The second course of sheets is secured to the first in the case of both walls and ceilings by an asphaltic or hydraulic cement, preferably the latter, the sheets being held in position while it is setting by means of wooden pins such as ordinary butcher's skewers.

### Securing Insulation to Surface

Mineral wool, vegetable matter and sheet cork are best erected against masonry walls in asphaltic or hydraulic cement, succeeding coats also being secured by the same material. When applied to ceilings, a method commonly employed is to run wires through the insulation, previously secured to the ceiling. When the second course of sheets is applied, chicken-wire screen, light iron rods

or both are closely secured against the under side of the insulation by means of the anchor wires, and the whole is plastered in the usual way. The chicken wire may also be used to advantage under a finishing coat of plaster applied to side walls in the case of the two last-named materials. With cork sheets either pure or natural its use is unnecessary. Impregnated cork should not be used on ceilings, as its binder asphalt has the property of slow deformation under continuous though slight strain, due to its own weight with that of the cement plaster.

# Sommerfeld Gas-Engine Plant

By W. O. Rogers

*SYNOPSIS—A block plant of 450-hp. capacity in the heart of the business section of Pittsburgh, Penn., sells electrical energy to patrons within a radius of nine city blocks, besides supplying the building in which it is housed. It is possible to start an engine and parallel the generator in less than half a minute. A home-made jump-spark ignition system has been applied to each engine.*

If an engineer were to pass No. 216 Second Ave., Pittsburgh, Penn., where the Sommerfeld Machine and Manufacturing Co. carries on a machinist business, there would be nothing to indicate that a block power plant was in operation in the six-story brick building occupied by the company.

Gas engines, running on natural gas, are employed as generating units. This plant, with a total of 450 engine horsepower, not only supplies the Sommerfeld machine shop, which occupies three floors, but serves the remaining floors of the building, and furthermore supplies electric energy for both lighting and power to numerous buildings embraced in nine city blocks in the vicinity of the plant.

There is every expectation that the load on the plant will grow in the future as it has in the past, and for several reasons. One is that the service is for 24 hours and is reliable; another is that there is no iron-clad contract compelling the user to purchase electric energy whether he wants it or not. If a customer believes he can obtain better rates and service, he is at liberty to discontinue all connection with the Sommerfeld plant and purchase energy from whatever source is available. The principal reason, however, is that the rates charged for the electric service are such as to warrant the purchase of this "block power" in preference to central-station service, and are such as to show a yearly saving over the cost of operating the individual isolated plants in various blocks, besides giving a fair profit to the Sommerfeld plant.

## Moving the Old Plant

As has been the experience of most successful machinists, the Sommerfeld company began business on a small scale in 1886. Up to ten years ago the works were in a one-story building diagonally across the street from the present site. Power was furnished by a small gas-engine plant in a low 25x35-ft. basement. The first unit installed was a 10-hp. engine, followed by one of 15 hp., both driving direct-current generators running in parallel. With the increase of business a 50-hp. engine was installed, and additions were made as the demand for electric current increased, until at the time of moving into the new building, four 50-hp. gas engines and the same number of direct-current generators were in operation, the small engines and generators having been dis-

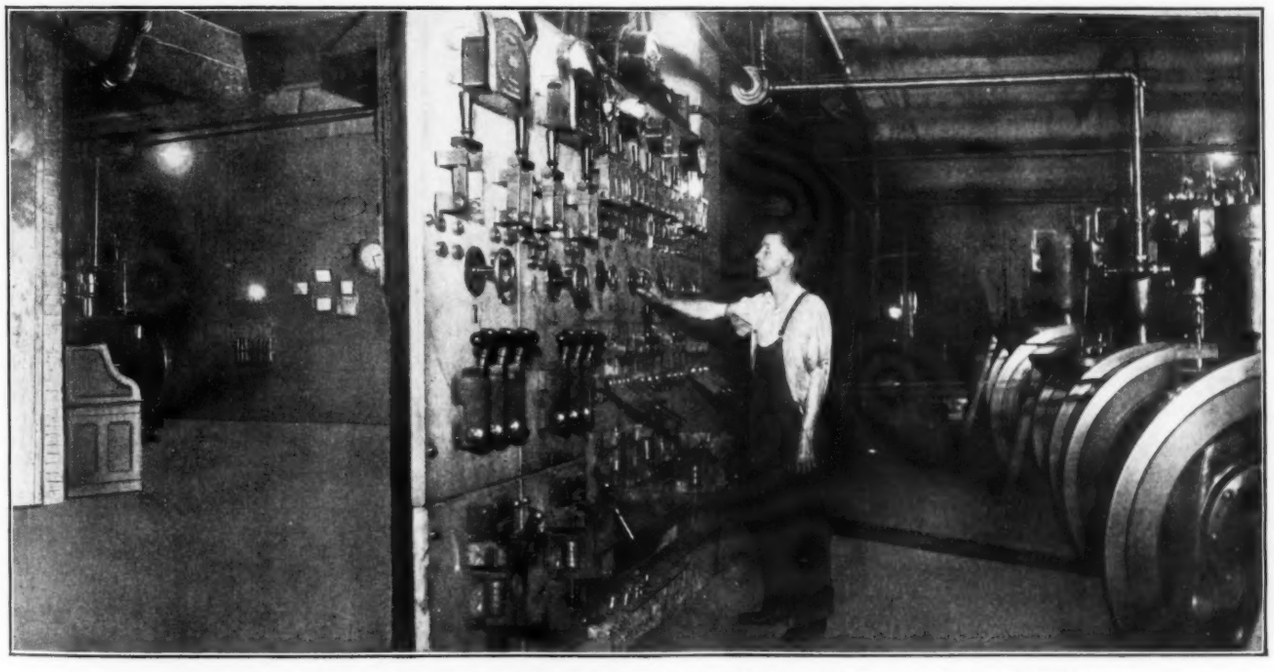


FIG. 1. VIEW OF ENGINE ROOM, SHOWING SWITCHBOARD IN THE FOREGROUND

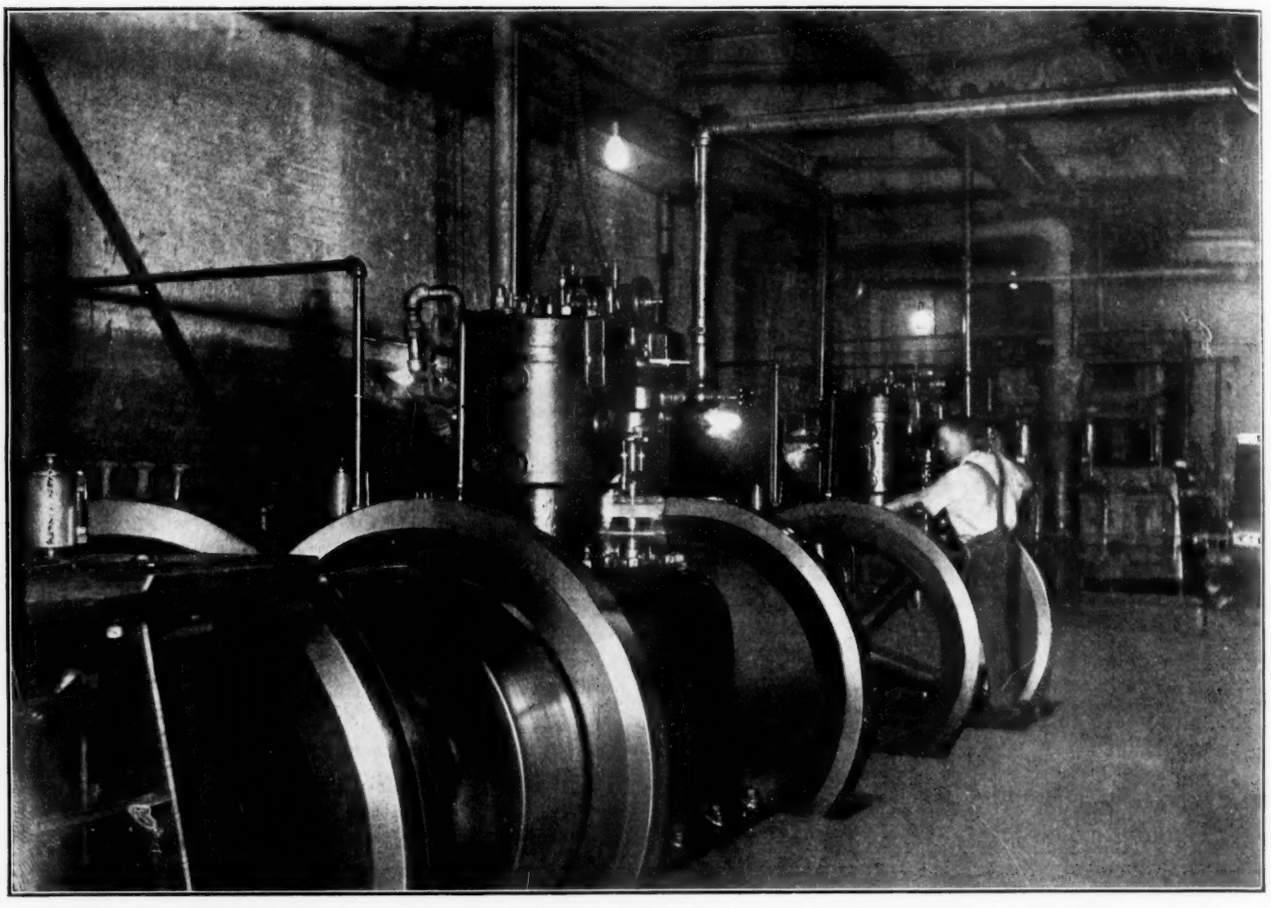


FIG. 2. ANOTHER VIEW OF THE ENGINE ROOM, SHOWING 125-HP. UNIT AT THE FAR END

carded. A profitable business had been built up in supplying light and power to adjoining property. Operations could not be interrupted without inconvenience and loss to the several customers, and it was necessary to move the power plant piecemeal.

One machine was moved at a time. Work on the first unit was begun at 6 p.m., after the machine shop had closed for the day. Chain block and jacks were used in moving the engine, and notwithstanding all the inconveniences surrounding the work, the engine and generator were installed, running and supplying current to the machine shop in the new engine room at 10 a.m. the next day.

The other engines and generators were moved in the same manner.

The new engine room contains two 85-hp. three-cylinder 11x12-in. engines directly connected to 115-volt direct current generators of 400-amp. capacity each and running at 290 r.p.m. There are also three 55-hp. 11x12-in. two-cylinder engines, each belt-driving a 115-volt generator of 320-amp. capacity at 656 r.p.m., the engine speed being 290 r.p.m. The largest unit is a 125-hp., three-cylinder 13x14-in. engine running at 260 r.p.m. and belt-driving a 115-volt direct-current generator having a capacity of 680 amp. and running at 600 r.p.m. The engines and the two directly driven generators are of Westinghouse make; the belt-driven generators are from the Commercial Electric Co. Figs. 1 and 2 are views of the engine room from opposite ends.

Owing to trouble caused by the electrodes of the ignition system burning unevenly, resulting in disarranging the timing of the spark and consequently causing the explosion of gas in the cylinder to occur at other than the correct point of the piston stroke, Mr. Sommerfeld decided to equip all of his engines with a jump-spark

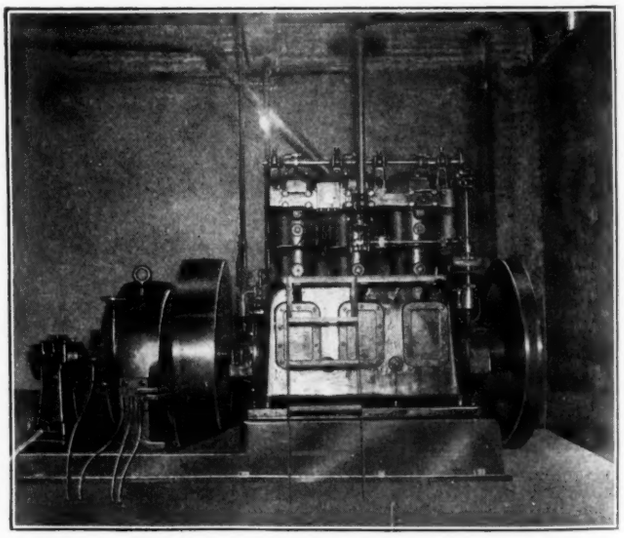


FIG. 3. ONE OF THE ENGINES EQUIPPED WITH JUMP-SPARK IGNITION

system of ignition. This consists of an ordinary spark plug in the head of each cylinder, an induction coil and a timer. The timers were made in the machine shop and are attached to the valve camshaft at the back of the engine. Fig. 3 shows the position of the spark coil

and the wire connections leading to the spark plugs and to the timer. The ignition current is supplied at 6.4 volts from either of two three-cell storage batteries. While one is discharging, the other is being charged. Fig. 4 shows one of the belt-driven units.

Compressed air for starting the engines is supplied by either of two Westinghouse air compressors at 180 lb. pressure. Water for house service and for cooling the engine jackets is supplied by either of two motor-driven deep-well pumps, which are in the engine room. The engines run on natural gas. Any unit in the plant can be started up and the generator thrown in parallel with the others in less than one-half minute. The writer saw this done with an engine that had not been run for at least a week, and the time was exactly 28 seconds, the engineer not exerting himself to make a record. These engines have been started up and the generator cut in on the line in 20 seconds where quick work was necessary in an emergency.

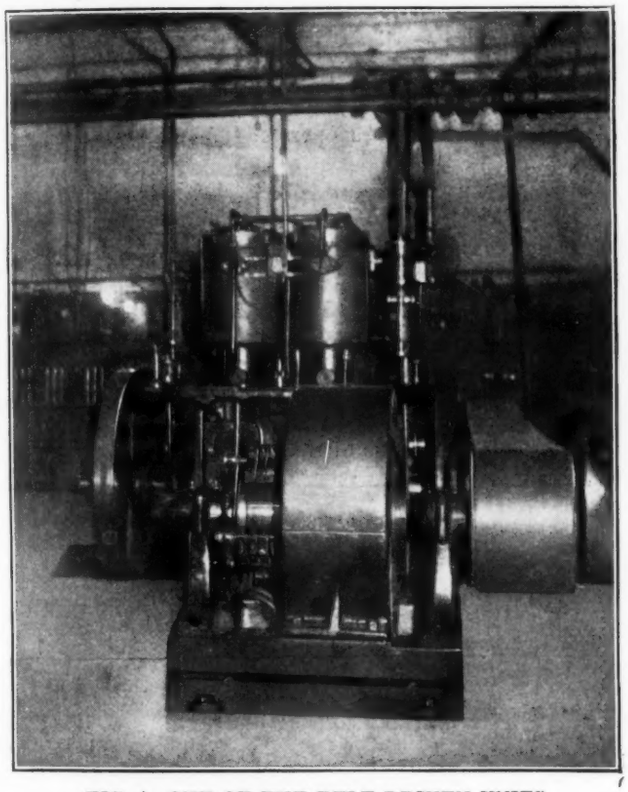


FIG. 4. ONE OF THE BELT-DRIVEN UNITS

This kind of operation indicates that the engines and generators are kept in the best of condition, which is doubtless due largely to the fact that the three men engaged for the 24-hr. run have all served in the machine shop and are practical machinists. The plant is in charge of Robert Wilkeivitz, chief engineer, and August and Joseph Roths are his assistants.

**The Total Friction** of a given engine remains practically constant under all loads and should not exceed 5 to 8 per cent. of the full-load capacity of the engine. It increases with steam pressure from 30 to 70 lb., after which only slight increase is noted. Increased speed generally increases the total friction, but not always.

**The Weight of Water Contained in a Pipe** 3 ft. long is closely approximate to the diameter in inches squared (multiplied by itself). For example, 3 ft. of 6-in. pipe will contain $6 \times 6 = 36$ lb. of water.

# JUST FOR FUN

## Anonymous but Good

One day recently the exhaust-valve stem on a 1,200-hp. Corliss engine broke. Mr. "Butinsky," who, after oiling in the plant for several years had attained to the position of assistant engineer and was wise only in his own estimation, wanted to know right away what the trouble was. "Why, the careless head oiler left a monkey wrench in the boiler drum and of course it came over into the engine with the steam," he was told. In his supreme contempt for a mere oiler he remarked: "That durn fellow is always doing something crazy, but then what can you expect of an oiler? He's not supposed to know things. But say! An assistant engineer has to know a lot."—John Doe, Kidder, Ky.

## All for the Want of a Few Tools

Not having tools, as "accessory before the fact," cost the price of repairing a building and a large engine, caused a broken arm and the loss of cash. The engineer went to a neighboring engine-room to borrow some tools and in passing a machine got his sleeve caught and had his hand pulled into the gears. In his absence the governor shaft on his engine stuck and the engine raced. The manager, who heard the noise from the office, ran to the engine room, but too late. The flywheel burst, tore a hole in the building and upset a tank of oil, into which the manager slipped, spoiling his clothes. The clerk in the office, being excited, also hurried out and forgot to close the safe, and some one helped himself to the cash. I wonder if it doesn't always pay to buy tools?

ACCOUNTS WON'T BALANCE

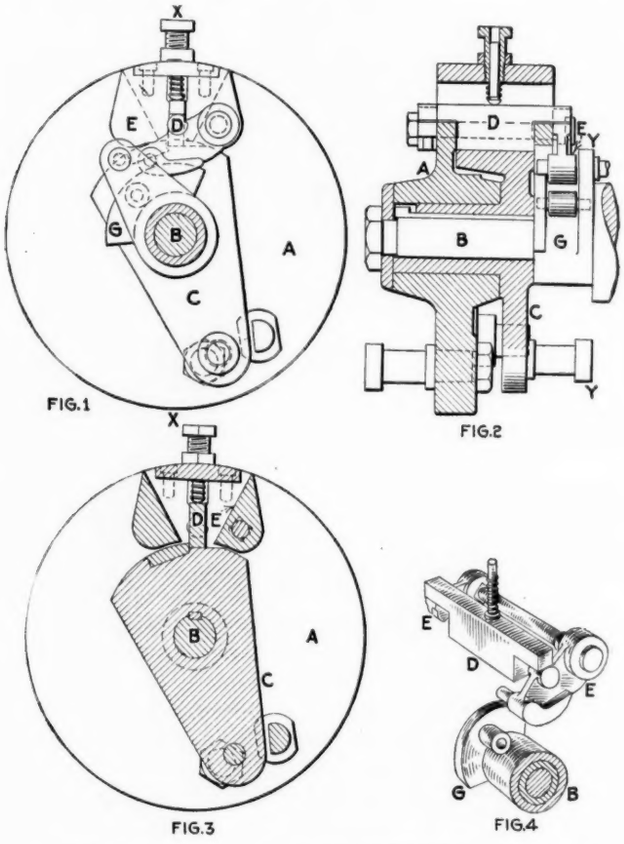
[No name or address is given with this contribution, so we cannot remit. Please don't all speak up at once.—Editor.]

## Water Had the Steam Boiled Out

I went as engineer to a branch plant of a Chicago company located up-state in Wisconsin. The first morning on the job I noticed that "Rube," the fireman (who I was told, was a "first-class engineer"), opened the blowoff every half-hour. As Reuben had handed me the frozen mitt that morning when I ventured in the "biler" room, I hesitated to go in, but my nerves wouldn't stand for it longer. "Why do you open the blowoff so often?" I asked. He gave me a glance of withering contempt for my ignorance and then fairly yelled at me: "Why, to let fresh water in 'er, of course." Having noted the continuous operation of the feed pump, I asked: "Is this intended as a joke?" "Naw, 'taint no joke." "Well, I don't believe I understand," said I. He seemed fairly to swell up with contempt for my stupidity, then he exploded: "Why, —— —— ——, don't you know enough about this here engineer business to know that when you bile water a little while that you bile all the steam out of it and you gotta put in fresh water what's got steam in it?"—R. C. Smith, Chicago, Ill.

## Trip Gear for Corliss Valves

The accompanying illustrations relate to a radial trip gear for Corliss valves with a trip piece having a rectilinear movement radial with the valve spindle, for which, according to the *Mechanical Engineer,* a patent has been granted to Joseph Taylor, Soho Ironworks, Heywood, Lancashire. It is designed to provide a trip gear having a square or straight lift on the trip piece whereby the wear on the two wearing edges and the liability of slipping are reduced to a minimum and the engagement of the parts rendered more certain, especially suitable for quick-running engines.




FIGS. 1 TO 4. DETAILS OF CORLISS TRIP GEAR

Fig. 1 is a side elevation with parts shown in section on the line *Y Y*, Fig. 2; Fig. 2 a transverse section on the line *X X*, Fig. 1; Fig. 3 a section elevation and Fig. 4 a perspective view of the trip piece *D*, tappets *E* and quadrant bracket *G*. The operating disk *A* is mounted upon the valve spindle *B* and is caused to oscillate around it in the usual way, and the valve lever *C* by which the valve spindle *B* is oscillated or rocked is secured to the latter by a key. The disk *A* carries at its upper end a trip-gear case in the form of a bracket in which is fitted a sliding trip piece *D* with a rectilinear movement giving a straight or square lift radial to the valve spindle *B* and valve lever *C*.

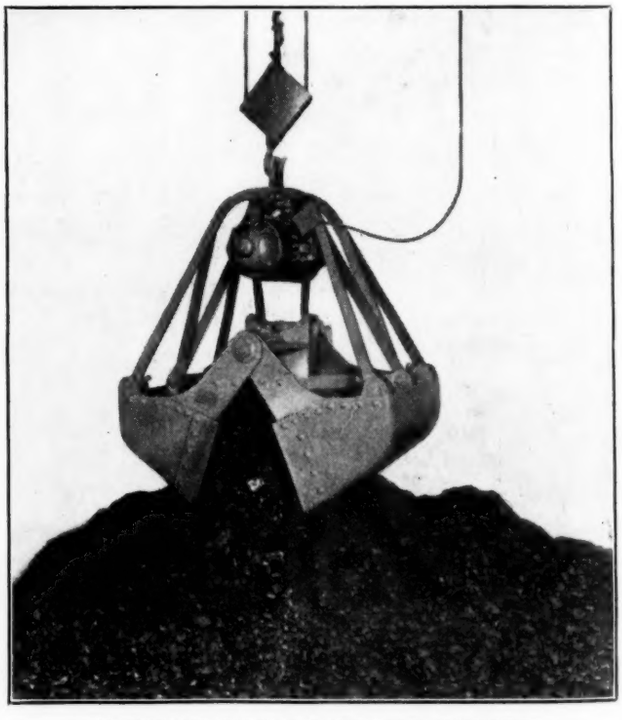
The trip piece *D* is forced into contact with the face of the valve lever *C* by a spring and pin, the pressure of the spring being regulated and adjusted by a guide screw passing through a crossbar fitted to the top of the gear case. The ends of the trip piece *D* project laterally through slots in the sides of the trip-gear case and rest upon tappets *E* by which the trip piece is raised out of engagement with the valve lever *C*, the tappets being mounted on a transverse spindle passing through the gear case to rock simultaneously. The tappet *E* is made with a depending member by which it is actuated. Adjacent to it, a stud or runner is mounted on a quadrant bracket *G*, over which it rides at each stroke of the operating disk lever *A* to raise the trip piece *D* to release the valve lever *C*. The face of the valve lever *C* is fitted with a renewable wearing piece with which the trip piece *D* engages.

## Hayward Electric-Motor Bucket

The Hayward electric-motor bucket, illustrated herewith, is similar in design to the regular clamshell bucket built by the Hayward Co., 50 Church St., New York City. Attached to the upper center is a motor-operated winding mechanism which opens and closes the jaws of the bucket, making it a self-contained electrically operated unit which can be operated from any convenient location.

The transmission multiple-disk clutch is designed to slip, which permits the motor to run continuously in case the edges of the bucket come together or are held apart by some obstruction while the controller is in the closing position. This feature prevents the liability of damaging any of the apparatus.

The motor is governed by a controller connected to the motor by a waterproof conductor cable. By throwing the controller handle in one direction the bucket closes and stops automatically when the jaws meet. A reverse motion of the handle opens the bucket. The movement of the handle also controls the amount of material the bucket will pick up. All moving parts are inclosed in a heavy casing. The buckets are built in capacities from ¾ cu.yd. up and are equipped with either direct- or alternating-current motor for the available electrical energy.



HAYWARD MOTOR-OPERATED BUCKET

# Editorials

## Did They Find the Man?

The State Civil Service Commission of New York recently issued circular No. 261 regarding an examination for inspector of heating, lighting and plumbing. The office carries a salary of twenty-two hundred and fifty dollars.

This competitive examination was open to men not under thirty years of age and all eligible candidates were required to have had at least five years' actual experience in the operation or installation of heating, lighting and power plants, and not less than one year's practical experience as foreman, as master steam fitter or plumber. They were required to be fully acquainted with the methods of determining the efficiency of different kinds of fuel, fully conversant with different classes of steam boilers and types of steam engines and electric generators and the respective merits of each for different requirements, and the method of determining the efficiency in a particular installation. They were to be fully acquainted with the installation of modern plumbing, including principles of ventilation and hydrostatics and the elements of sanitary engineering as applied to plumbing generally.

No written examination was to be given, but candidates would be rated upon age, training and experience and personal qualifications. An oral examination, it was stated, "may be held."

An analysis of the circular indicates that either the commissioners have not realized the immense scope of the requirements or they do not expect to fill the office of inspector. Where do they hope to find, at the salary stipulated, a candidate who is an engineer and a plumber, and who is fully conversant and able to qualify regarding all the requirements demanded by the commission?

Of course, the commissioners have their ideas regarding the method of determining the fitness of a candidate to fill the position of inspector, but how is he to produce the evidence that he possesses the necessary qualification if no suitable examination is held, assuming that there is an application for the office?

What has age to do with the position? A man thirty years old might easily possess a broader understanding of the subjects mentioned than one sixty. How is the commission going to judge of one's training and experience without an examination other than taking the written statements in the application of a candidate as evidence? Is it not a fact that a gold-brick confidence man can present an array of arguments sufficient to convince some that prunes are peaches? Do they expect to determine a man's fitness by the color of his eyes or the girth of his waistband?

Experience has proved that the capable, experienced man is more likely to refrain from setting forth his knowledge to the full because he knows that there are many things of which he is not a past master, and because of this diffidence he will not appear to the same advantage as the "bluffer" who claims all things for himself, while knowing that he is altogether deficient.

So far as we are able to judge, the successful candidate for the position (if there is one) will not be selected because of his all-round qualifications or because he is the best man, unless he is examined to ascertain how much he does know. Certainly a man may have a smattering of all of the branches mentioned in the circular, but who ever knew of a master plumber, steam fitter or a mere plumber who knew or was supposed to know anything about steam engineering and power-plant efficiencies?

Furthermore, plumbing and steam engineering have no connection whatever. Each is in a field by itself, and an attempt to combine the two will result in a hodgepodge.

Better would it be to split the office into two branches and then men will be available who can fill the positions on their merits and not on a pretty array of statements.

## Safeguarding Crane Service

In many generating plants equipped with electric cranes long periods of disuse occur between hoisting operations. The infrequency of this service tends toward the omission of safety measures which are widely applied in industrial plants, but which are none the less important to the welfare of the station staff. The policy of letting the crane stand idle from one month's end to another is a poor one, since occasional trial runs afford opportunity for inspection and oiling, besides affording new and less experienced men the opportunity to familiarize themselves with the use of the controllers, brakes, slings and switches.

An important point in crane operation is for the operator never to go to the top of the crane or to permit anyone else to do so without opening the main switch and placing a warning sign or lock upon it; and conversely, to refrain from closing the switch until certain that no one is likely to be caught either on the crane or its runway. Common sense would seem to indicate the necessity of observing that the hook and chain are high enough to clear all obstacles before moving a crane, and yet disastrous short-circuits have resulted from neglecting this precaution. The mounting of generator rheostats on pipe-framing within reach of crane chains has been noted often enough to warrant the suggestion that the location of this equipment under galleries or with adequate top screening be given more thought in designing.

Although the chances of accident are far less in a power plant, on account of the relative infrequency of the service, the practice of running loads over men on the engine-room floor is to be condemned; as is also yielding to the temptation to ride on the load or the hooks. The vigorous use of the bell or whistle is a *sine qua non* of safe service, as is the testing of brakes when handling heavy loads after these have been lifted a very few inches, with the shutting down of the equipment if the brake does not hold the load properly. The damage some ma-

chines receive from a comparatively small drop is often great in cases where the brake weakness has not been discovered in time.

Regular inspection for loose or defective gears, keys, switches, runways, warning signals, cables, etc., is important, and the fireproofing of the cage floor by asbestos board on steel plate, the furnishing of the cage with an approved chemical extinguisher and the provision of metal tool boxes permanently attached at convenient points in the cage or on the runway are useful aids to safer service.

## Handling Men Efficiently

The larger the power plant the greater is the problem of handling the men successfully, and it is one of the most important with which the chief engineer has to deal. In fact, in larger stations executive duties are by no means confined to the chief, and the knowledge of what to avoid, as well as of what to practice, in directing the work of others is very valuable. The control of men can never be an exact science, because no two men are alike, and the personality of each superior is a factor. At the same time there are a few general principles bearing upon the handling of subordinates, which are often overlooked and which, if carefully and tactfully observed, will do much to facilitate the work of the plant.

Every subordinate should watch his superiors to learn the desirable and also the undesirable methods of handling men. Imitation, however, must be tempered by common sense. Thus one chief engineer may have a humorous but, in his case, highly effective way of holding subordinates up to ridicule for certain minor faults that would be a flat failure if attempted by another. Sincerity is fundamental in such work; to copy another person without his qualifications is fruitless.

In all relations with men a chief engineer or department head must be firm, but square and consistent. Nothing destroys the efficiency of a station organization faster than partiality. So long as an executive is fair he may be as strict as he pleases, always requiring the best of his men. Breaches of rules cannot be laughed away one day and reprimanded the next. Again, withholding action while angry is advisable. Nothing is lost by waiting until the executive temper is under control if the immediate service of the plant will permit it.

Arguing with a subordinate over the carrying out of orders is poor policy, and any discussion with an employee in the slightest degree under the influence of liquor is wasted energy. The fulfilment of the order is the first essential, and the reasons for its giving can be explained later if it is desirable, and it usually is, for every effort should be made to increase the interest and understanding of subordinates in the work. Sometimes an employee is reported to the chief for refusing to obey the instructions of a superior. Except rarely, the first and only thing to do is to ask the nature of the order and ascertain whether it has been carried out. After the task is completed is the time to investigate the wisdom or justice of the instructions.

When apparent conflicts arise in station duties the last order should always be obeyed first, if given by one in authority, whether he be the senior superior or not, if after being apprised of the previous order he does not revoke his own. Then the one giving the first order should be told why his was deferred or not carried out.

Airing one's knowledge by giving needless advice is most irritating to one capable of handling a job efficiently. Good men should be encouraged in initiative, holding them responsible for results rather than methods, just as the chief expects his employer to allow him to perform his duties in his own way. Detailed instructions should be given only where necessary.

If the chief has occasion to take charge of the fireroom for a period, it should be made clear that the boiler-room engineer is relieved from direct supervision for the time being, since nothing creates greater confusion than giving orders over another man's head.

The quieter an executive is in the usual performance of duty, the more action he will get when occasion demands. To shout at men when speed is wanted, if they are already working as fast as possible, is inexcusable. When men are pushing and doing their best, they will complete their work more rapidly if let alone, as long as the job is being properly done.

To run off a successful watch in a station, the executives must be on the alert because their actions are insensibly reflected by those of even the lowest-grade subordinates. Prompt response to all calls should be required. If a watch officer habitually calls his subordinates two or three times, they will never jump the first time he calls. A single standard of plant inspection, also, is worth considerable effort to maintain. Finally, willingness to admit a mistake is one of the best possible means of retaining the respect and loyalty of one's subordinates. The more efficient an executive engineer is the oftener he is right, but when he is wrong it is merely compounding the error to try to bluff it out.

## The Language of the Law

The main purpose of language, written or spoken, is to convey information, to communicate ideas. Its improper or slovenly use is an indication of the mental training or habit of its user, but if it does not positively and definitely express the idea which was in the mind of the writer it has failed in its real object.

In the language of laws and rules which men must apply to the affairs of life and of business no ambiguity is permissible, no chance for a dual interpretation is to be tolerated; and public documents should not, figuratively speaking, eat with their knives, but should be examples of the fairly correct use of the language in which they are written. In the stress of getting laws and rules adopted, often against stubborn opposition to any regulation at all, oftener with the necessity of compromising conflicting interests, weird combinations of words are a frequent outcome, and the proponents of the measure are too glad to get it through to risk amendment, even for the simple purpose of ironing out the grammar. It would be an excellent thing if every legislative measure or set of rules and regulations could, before its final adoption, be gone over by a sort of literary valet who would not be suspected of ulterior motives if he transposed a split infinitive.

The legislatures are convening, and committees are getting ready for the periodic struggle for license and inspection laws, smoke abatement regulation, etc. Let us hope that such laws will be read from a literary as well as from an engineering and legal point of view, before they are spread upon the statute books.

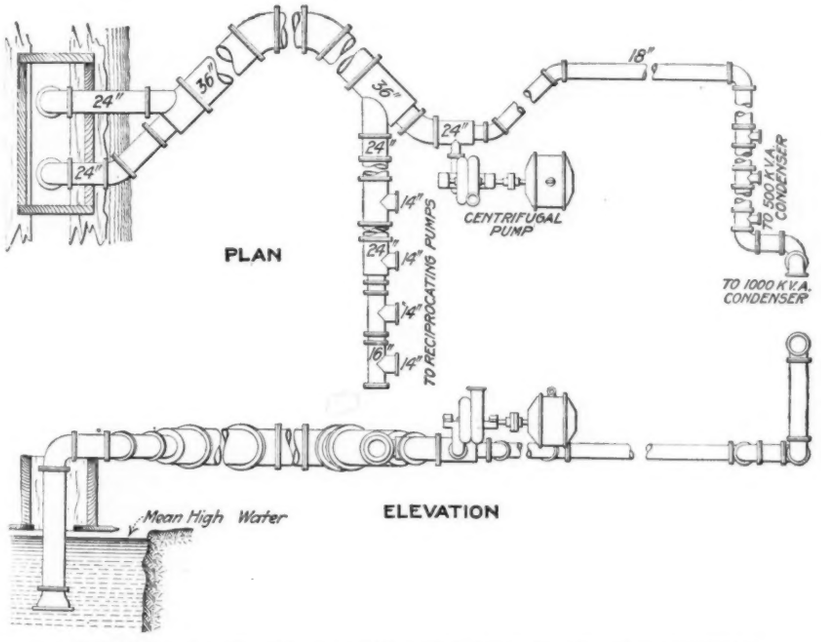
# Correspondence

## Difficulty with Suction Line

For a time in the centrifugal pumping plant under my supervision considerable trouble was experienced with an 8-in. two-stage turbine-driven centrifugal pump.

The common suction line to a group of pumps and condensers is 36 in. in diameter for 90 ft., then it reduces to 24 in. at a Y-branch leading to four reciprocating pumps; the other 24-in. branch is 30 ft. long to a centrifugal pump, then the line reduces to 18 in. and is 54 ft. long, connecting two Le Blanc condensers, one for a 500- and the other for a 1,000-kv.-a. turbine. The layout is not good, but the suction lift is only 4½ ft.

The centrifugal pump was originally equipped with an ejector that would work all right at high water, but at no other time. A vacuum gage was placed in the suction line, and it showed 28.2 in. of vacuum. The condensers on the turbines carry a vacuum between 28.5 and 29.2 in. The best vacuum that could be obtained by the ejector was 27.4 in. As this was not as great as the vacuum in the suction line, it was easy to see where the trouble was.




GENERAL LAYOUT OF SUCTION-LINE PUMPS AND CONDENSERS

We now use a water seal around the glands and start the pump slowly with both the discharge and suction valves closed and gradually bring it up to full speed and continue until the vacuum gage shows 29 in.; next the suction valve is slowly opened until fully open, then the discharge valve is opened. Since operating in this manner there has been no difficulty in getting water.

Owing to the position of the intake, the foot valves clog up with mud, grass and trash found in tidal water near a large city. This greatly restricts the passage of the water and no doubt accounts for the high vacuum on the suction line with the small lift. There is undoubtedly a waste of power.

ALEXANDER ARNOIS.

Philadelphia, Penn.

[The conditions described merit a discussion that will no doubt prove profitable.—Editor.]

## Economizers in Modern High-Pressure Power Plants

In the Oct. 12 and Oct. 26 issues, respectively, there appeared communications from George C. Usher, of the Green Fuel Economizer Co., and William N. Rose, of the B. F. Sturtevant Co. The authors of these communications question the thoroughness of the investigation which led to the following statement in a paper descriptive of the Connors Creek plant of the Detroit Edison Co.:

> Failure to install such apparatus must not be understood as a declaration of disbelief in its efficiency. It is, however, felt that the cast-iron-tube economizer as now built and operated at full boiler pressure is not a proper piece of apparatus for installation in a modern high-pressure plant. Because of the high efficiency attainable with the large boilers, it was therefore deemed advisable not to install economizers until such time as a more satisfactory type or a more acceptable method of operating is produced.

This decision was reached by the engineers in charge of the design of this plant after they had had considerable experience with the operation of cast-iron economizers of an older design than those referred to in the communications mentioned, and after they had become thoroughly familiar with the experience of other companies using newer forms.

I do not desire to start a discussion of the much disputed economizer question. Whether economizers should or should not be used is easily determined on a monetary basis, if it be assumed that suitable apparatus is available at a known cost, and with a known thermal performance. Nor do I desire to question the quality of the products made by the companies these two gentlemen represent. However, I do want to present the point of view which led the engineers responsible for the design of the Connors Creek plant to arrive at the decision stated in the paper.

Briefly, they made no objection to new cast iron; it is cast iron that has been alternately heated and cooled while under a considerable tensile stress to which they object. They are satisfied that just as cast-iron mud drums, headers and other boiler parts have given way to steel for the higher pressures, so economizer parts must ultimately be superseded by parts made of a material better adapted to resist the severe conditions of use to which economizers are subjected. They feel the necessity of

such a change particularly because of the higher steam pressures which are now being widely discussed, which have actually been adopted in a few cases and which will undoubtedly be widely adopted in the near future.

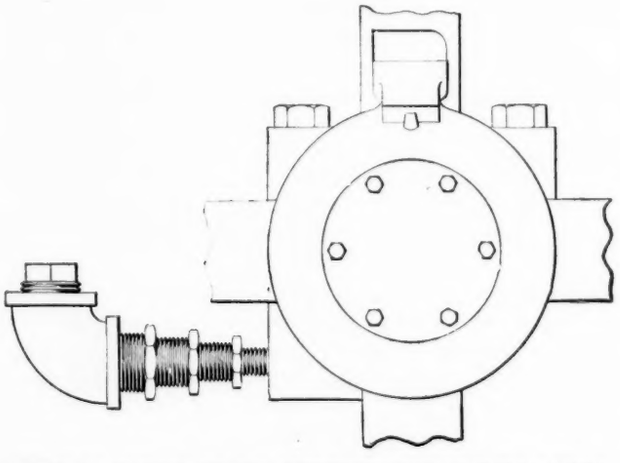
They are willing to admit that the conditions under which economizer parts generally operate are different from those obtaining in the case of boiler parts, and they are further willing to admit that thorough and rapid circulation in a cast-iron economizer may materially increase its chances for longevity. But, after making these admissions, they do not feel justified in installing such economizers in a plant operating with a steam pressure of 225 lb. per sq.in. and a correspondingly higher feed-water pressure.

Their decision is further influenced by the belief that economizers made of what, to them at least, appears to be a more satisfactory material will be available shortly, and by the further belief that with this change in material will come such changes in design and location as would make the present form of economizer obsolete before it had been in use for a sufficient length of time to justify the purchase. C. F. HIRSHFELD.

Detroit, Mich.

## Oil Reservoir Too Small

A 1½-hp. direct-current motor rated at 1,450 r.p.m. is attached to a pump used with a vacuum heating system. From the first it was a constant source of worry on account of hot bearings, which are of the ordinary ring-oiled type. The manufacturer's error consisted in not providing oil wells of sufficient capacity for the size and speed of the motor. One liquid ounce (about 1¾ cu.in.) filled the wells to overflowing. On account of the



HOW CAPACITY OF OIL RESERVOIR WAS INCREASED

relatively high speed, the normal running temperature of the bearings is high, resulting in rapid evaporation of the oil. The consequence was that unless the bearings were closely watched and the oil frequently replenished, bearing trouble resulted.

A remedy was effected by providing what might be termed auxiliary oil wells. The oil-well drain cocks were removed from the frame and in their places were screwed ⅛-in. close nipples; to each of these nipples was attached a series of pipe bushings and an ell, as shown in the sketch. This arrangement has the effect of greatly increasing the well capacity. The top of the ell is on a level with the overflow point of the original oil well, so that when the ell is full the original well is also full. A loose-fitting plug serves as a cover for the ell. The rate of evaporation is the same, but the auxiliary well provides a reserve supply of lubricant that automatically finds its way to the original well, replacing the oil that is evaporated from there.

The small capacity of the oil chambers would not be of so much consequence but for the fact that the motor is situated in a building several hundred feet from the engine room. The engineers have other apparatus to look after and sometimes find it impossible to make frequent trips to this isolated heating plant. Before these auxiliary wells were put on it was not unusual to find at least one of the bearings entirely dry and the other in only slightly better condition. H. G. GIBSON.

Washington, D. C.

## How We Look to the Other Fellow

A level-headed friend of mine, who has charge of the correspondence of a large supply house and receives and answers perhaps a thousand letters from engineers each month, the other day gave me his opinion of engineers in general, after he had finished reading another article in *Power* advocating engineers as salesmen, purchasing agents, etc. I cannot quite agree with his views, but will pass them along.

"It is about time for some of you engineers to begin to learn some of the things you ought to know. This letter is a sample"; and he tossed me a letter from the engineer of a small power plant, which read as follows:

> Please ship one 3-inch blowoff valve. We carry 100 lb. of steam on our boilers and we want a valve that will not let out too much steam. Please let some practical man fill this order, as he will know what we want.

"Can you tell me what he wants? Does he want a blowoff valve to let water out of his boiler, or does he want a pop safety valve? You don't know, do you? Neither did I until I wrote and finally found out that he wanted one 3-in. pop safety valve set for 100-lb. pressure and he wanted one that would not let the steam pressure drop too far before closing.

"Here is another one; he wants two 6-in. flanges with 6 holes to match the flanges he already has in place. Wouldn't you think he would give the outside diameter of the flanges, the size of the holes and the bolt circle? He was delayed a week in receiving the material by his own ignorance. I know this engineer has our catalog giving all the measurements of flanges and fittings, and there is absolutely no excuse for writing an order in this manner.

"Here is another, returning a 6x4x6 cast-iron tee and asking for a 6x6x4 in its place. He didn't know how to read a tee. It seems to me that about half of the engineers do not know that you read the run or the two ends of a tee first and the side outlet last, naming the larger of the run ends first. Most manufacturers' catalogs give such instructions.

"These incidents are almost daily happenings, and they are just the ones that keep you engineers from doing your own purchasing, as your employer loses confidence in you after causing serious delays.

"Engineers complain that manufacturers and jobbers will not send them catalogs so that they can order intelligently, while there are very few requests for catalogs that are not complied with and there would be less if the catalogs that are sent out were studied in place of being consigned to the furnace.

"The engineer that takes care of his catalogs and studies them the most is the one that has few kicks and the least friction with his employer. What you engineers need is to learn your own business first, and if you really learn it you will receive a salary that will keep you from accepting positions outside of your own line."

Kansas City, Mo. H. G. SCHULER.

## Favors Breakdown Service

I agree with the statement in the item, "Bolt Prevents a Shutdown," on page 722 of the Nov. 23 issue that a lantern is handy to have around a power plant. However, electric lights are much handier and a plant that runs nights ought to have something besides a lighted lantern as an auxiliary. If it is impossible to have reserve units, it would be well for such an emergency to have a connection with central-station service. At best a shutdown for a factory is expensive, and all precautions against it are good investments. This was forcibly brought home to me recently. A factory, to catch up in its work, had to run nights as well as days. One night the lights went out and the night force had to go home. As a result the output was decreased, affecting the owner, and as the plant was shut down for a few nights, the employees' pay was also affected. "An ounce of prevention is worth a pound of cure," even if "despised" central-station current has to be used.

Sometimes central stations do not properly look after their own house lights. In one plant of the kind the house lights were connected to one of the commercial circuits, and whenever that circuit failed through some outside trouble, the house lights went out also. The situation was somewhat relieved by having a few gas jets installed, but they did little more than dispel the gloom, for when the engineer had to go around the engine he could not see the oil in the sight feeds.

Middletown, N. Y. G. T. MICHAEL.

## What the Modern Power-Plant Engineer Must Know

In the Oct. 26 issue of *Power*, page 590, is an editorial comment on the paper, "The Future of the Operating Engineer," by John B. McGowan, read before N. A. S. E. No. 8, of Brooklyn, N. Y. The comment mentions that Mr. McGowan tells of an aspirant for a desirable position, who had succeeded so far as to be invited to appear before a committee for examination as to his qualifications. Two of the questions asked of the applicant were: "Mr. Blank, the appraised valuation of this plant is $53,000. What in your estimation should be the rate of interest on the investment? What proportion of the fixed charges would you credit to depreciation?"

These questions may be good to determine a man's business ability, but most engineers would consider them hardly fair. I believe that most public accountants would refuse to answer the questions as put, for the reason that the information given is too meager. They at least would request time to analyze the condition of the plant.

I have had some opportunity to observe the many answers to the question of what should be the depreciation rate, and it is indeed surprising how widely varying the rates are as given by various appraisers.

The following is the appraised valuation of a plant that cost on May 1, 1913, $55,000; the various charges are itemized:

INVESTMENT CHARGES

| | |
|---|---|
| Land | $3,000.00 |
| Buildings | 7,500.00 |
| Rolling stock | 11,500.00 |
| Power plant | 33,000.00 |
| Total investment | $55,000.00 |
| To 2½ yr. interest at 6 per cent. on investment | 8,250.00 |
| | $63,250.00 |

DEPRECIATION IN 2½ YEARS

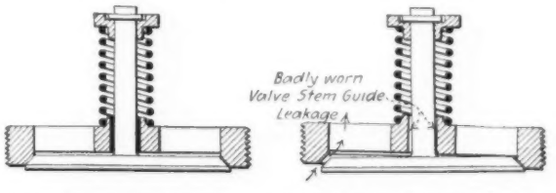
| | | |
|---|---|---|
| On rolling stock at 10 per cent. per annum | $2,875.00 | |
| On buildings at 3 per cent. per annum | 562.50 | |
| On machinery at 7½ per cent. per annum | 6,187.50 | |
| On land (depreciation governed by local conditions) | | |
| | | 9,625.00 |
| Net value of plant, Nov. 15, 1915 | | $53,625.00 |

A knowledge of initial investment, interest, depreciation, obsolescense, etc., is unquestionably far afield from the knowledge which engineers have heretofore been required to possess to carry on their work in a sound manner; it is a long way from valve setting, correct firing methods, pulley ratios, riveted joints, etc. The engineer must recognize, however, that in the larger plants, particularly, he will require some of the knowledge of the appraiser. HENRY W. GEARE.

New York City.

## Peculiar Case of Misfiring

A two-cylinder four-stroke-cycle gasoline engine would misfire occasionally in one cylinder. The spark plugs were cleaned, but this effected no improvement. When we closed down at night, the carbon was cleaned out of this cylinder and both inlet and exhaust valves were ground to a perfect fit; but after the engine was started




VALVE STEM GUIDE BUSHED — POSITION VALVE TOOK WITH WORN GUIDE

again the misfiring was as pronounced as ever. The compression was then tested by removing the priming cock from cylinder No. 2 and cranking by hand, thus feeling the compression in cylinder No. 1 only. However, the compression was found to be good. The engine was started again, and first one spark plug and then the other short-circuited. This at once developed the fact that No. 2 was doing all the work; for when the spark plug of this cylinder was short-circuited the engine stopped, whereas when the other was short-circuited the engine merely slowed down. This suggested that perhaps cylinder No. 1 was not getting any gas; but the counter argument immediately came to mind, how could such a thing be possible when both cylinders were fed by the same carburetor?

The timing in cylinder No. 1 was now checked by removing the priming cock in the head and inserting a

graduated rod, thus determining the position of the piston for all valve events and also for the ignition; but everything was found to be all right. New inlet and exhaust-valve springs were put in and the engine again started, but the misfiring continued with irregularity in cylinder No. 1.

Finally the air-inlet shutter on the carburetor was tried in all positions, but the misfiring continued on all mixtures of air and gasoline. During the adjusting, however, a spray of gasoline was felt against the hand. By observing very closely it was soon evident that the spray took place at the instant that cylinder No. 2 fired, and No. 1 immediately responded by misfiring. The solution to the trouble was now quite evident—the inlet valve on No. 2 could not be tight, as it allowed a jet of high-pressure gas to escape from the cylinder, out through the intake pipe, thus robbing cylinder No. 1 of its proper charge of gasoline from the carburetor.

The inlet valve on cylinder No. 2 was examined and found to have a perfect seat, but the valve-stem guide was worn badly, thus allowing sidelash, which caused imperfect seating and consequent leakage. The valve-stem guide was bushed to neatly fit the stem, the valve put back, and the engine has run perfectly ever since.

The symptoms of the disease were all in cylinder No. 1, but the disease itself was in cylinder No. 2.

Montour Falls, N. Y. E. HURST.

## Blocked Governor Burst Flywheel

At about 6:30 p.m. Nov. 2, the 10-ft. belt-wheel on a 14x36-in. Corliss engine in the municipal light plant at Milan, Mo., exploded, knocking out two sides of the building and wrecking the engine and a new 75-kw. generator. Nobody was injured.

It had been the practice to block the governor when the steam pressure was low. The cause of this accident was a blocked governor and the accidental catching of a piece of waste between the belt and governor pulley.

Green Castle, Mo. L. GRYLE CAMPBELL.

## Fan-Blower Blade Breakage

I was interested in the letter of Mr. Dunkley in the issue of Nov. 16, page 694, as I have had similar experiences in the breaking of fan blades. The fan shown in the illustration referred to is wrongly designed, as the blades are too wide and tend to vibrate in the center; in fact, the blades are constantly in a state of vibration while running at high speed and, in the course of time, will break. The balancing piece on the blade evidently hastened the result. The construction could be improved by putting the arms in the center of the blades. In my opinion curved blades are more rigid than straight ones.

In this district they use fans 12 to 13 ft. in diameter and 5 ft. wide for ventilating coal mines, and it is found that unless the blades are reinforced with angles they soon break.

Some fan makers have not yet learned that the so-called cutoff in fan casings is responsible for a good deal of breakage, as the blades vibrate every time they pass this obstruction in the air passage. In one case the cutoff was but 1 in. from the blades in a 12-ft. fan, and the blades lasted only about 3 months, so the cutoff had to be changed to 6 in. and the blades rounded off to a 6-in. radius. This cutoff is built into a 24-in. brick wall about 8 ft. above the ground, yet by placing one's hand on the wall the jar can be felt every time a blade passes it. The best running fan I have seen was about 10 ft. in diameter and 3 ft. wide, and ran in a casing about 15 ft. square; this gave the air a free course away from the blades at every point.

A low-head centrifugal pump, lifting a mixture of mud, water and scrap iron, as they do in dredging, has no such a thing as a cutoff. Why should these obstructions be placed in fan casings? A. H. HALLADAY.

Spring Valley, Ill.

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Mr. Dunkley does not state nor does the illustration show the method used to fasten the twin hubs to the shaft. Of course one method is as good as another if it holds the hubs securely to the shaft.

The failure with which I am conversant was due to one spider hub being loose and lagging behind the tight side when starting and trying to run ahead of the tight side when slowing down, causing the blades to bend until they finally broke. The balancing weight riveted to the blade no doubt contributed to the failure. The new fans with straight blades won't help much, but will leave the fan as a whole a little more flexible; and if a hub gets loose there may be a little more time before the collapse comes, but more than one blade will let go.

It is quite likely, however, that the vibration of the fanblade was localized at the point of failure by the counterweight in the case cited. JOHN POWERS.

New Bedford, Mass.

## Opening a Wedged Valve

The following experience is related, as I believe the remedy found saved the cost of a new valve, the labor of installing it and also removed the annoyance of a valve that always stuck when shut.

The valve referred to is on a 4-in. horizontal steam line, and two stems had been twisted before I found that by tapping on the rim of the bonnet lightly all around at right angles to the stem, with a hammer, and at the same time keeping a strain on the wheel with one hand, that the valve opened nicely, and the stem has not broken since. H. L. STAFFORD.

New York City.

## Stopping the Pulsations in the Feed Line

The article, "Stopping Pulsations in the Feed Line," in the Oct. 19 issue, is interesting as evidence of what might be done where there is trouble caused by using direct-acting boiler-feed pumps already installed.

The best way to stop pulsations is to avoid them by using a centrifugal pump in the first place. With such a pump the flow is even and there is no pulsation. The wear and tear on the feed line, valve, etc., is then avoided without using a special receiving chamber. Centrifugal pumps are not adaptable for boiler-feed operation for boilers of much less than 500 or 600 hp.

Hartford, Conn. J. BRESLAV.

# Flow of Superheated Ammonia Through Orifices*

By Prof. Edward F. Miller†

*SYNOPSIS—Experiments on the flow of superheated ammonia through orifices show that a true Napier orifice must have its entering edges rounded to at least 0.5 the diameter and that the length of the straight hole should be 1.5 times the diameter. Smaller dimensions introduce errors, but the entrance radius may be more than 0.5 the diameter without affecting the absolute pressure at the end of the orifice, which, with a true Napier orifice, will be 0.585 of the absolute initial pressure.*

This paper gives in brief the results of experimental work carried on by Messrs. Fairbanks, Williams and Miller, members of the Boston Committee on Ammonia Safety Regulations of the American Society of Refrigerating Engineers, and by Prof. C. A. Read, Worcester Polytechnic Institute, and by G. H. Clark, of the Massachusetts Institute of Technology. The experiments were made at the Sargents Wharf plant of the Quincy Market Cold Storage and Warehouse Co., Boston.

Orifices of different diameters, of different lengths and with different radii of entrance curves were tested. The gas discharged through orifices was taken into the suction side of a 1,000-ton compressor run just to take care of this gas. The gas entering the orifices was discharged from a 26x48-in. double, single-acting compressor run at speeds varying from 20 to 54 r.p.m. The temperature and pressure of the gas entering the compressor were noted.

The weight flowing through the orifices was calculated (after the pressure in the orifices had been determined) by making use of the theoretical formula given later. The weight of gas through the orifice per minute having been calculated, the volume reduced to suction pressure and temperature was calculated and the volumetric efficiency of the compressor determined. This volumetric efficiency was calculated merely as a matter of interest, although it did serve as a rough method of checking results.

## DISCHARGE OF AMMONIA SAFETY VALVES

$$\frac{c \times \pi \times d \times d \times 0.707 \times 290 \times 60 \times 0.4}{6\sqrt{700}} = \frac{\text{Piston displacement cu.ft. min.}}{5.665}$$

$$\text{Piston displ. cu.ft. per min.} = 551.67 \times c \times d^2.$$

The factor c is a coefficient used to allow for the shape of the orifice and was taken as 0.85 for a ½-in. valve, 0.90 for a ¾-in., 0.93 for a 1-in., and 0.96 on sizes 1¼-in. and over; 290 lb. abs. is the head pressure.

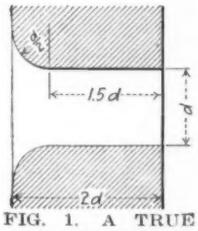


FIG. 1. A TRUE NAPIER ORIFICE

The value 5.665 is the volume of 1 lb. of saturated ammonia at 50 lb. abs., which was considered as sufficiently high for the suction pressure. That the displacement efficiency of the compressor is less than 100 per cent. gives an additional margin of safety to the values. The value 0.707 is the sine of 45 deg., the effective lift being only this proportion of the actual lift on a 45-deg. seat. The vertical lift of the valve at rating is taken as ⅓ of the diameter; 700 is taken as the absolute temperature of the ammonia gas leaving the compressor, or 460 plus the thermometer reading in degrees Fahrenheit.

RELIEVING CAPACITY OF AMMONIA SAFETY VALVES AT 290 LB. (ABS.) PRESSURE

Expressed in terms of piston displacement of compressor in cu.ft.

| Diameter of Valve, In. | Cu. Ft. Piston Displacement Per Min. |
|---|---|
| ½ | 117 |
| ¾ | 279 |
| 1 | 513 |
| 1¼ | 828 |
| 1½ | 1,192 |
| 2 | 2,118 |

These values are shown in Fig. 2.

The diameter of the discharge outlet and of discharge pipe 100 ft. in length, which would be required to care for this gas with 5 lb. accumulation in pressure at the entrance

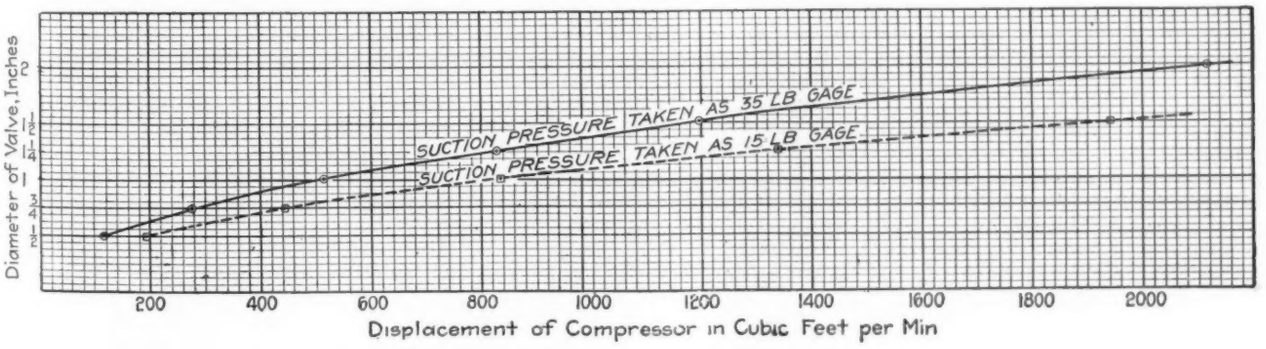



FIG. 2. DISCHARGE CAPACITY OF AMMONIA SAFETY VALVES AT 275 LB. GAGE PRESSURE

It appeared that with an orifice made as in Fig. 1, the absolute pressure in the orifice was 0.585 that of the absolute pressure at the entrance to the orifice. For such orifices the simple empirical formula was found to give reasonable accuracy and was used in calculating the discharge capacity of safety valves.

$$\text{Wt. per sec.} = \frac{0.4 \times \text{area orifice in sq.in.} \times \text{head press. abs.}}{\sqrt{460 + \text{head temperature deg. F.}}}$$

*Abstract of a paper read before the December, 1915, meeting of the American Society of Refrigerating Engineers.

†Professor mechanical engineering, Massachusetts Institute of Technology, Boston, Mass.

end and with atmospheric pressure at the exit end, was figured by the Babcock formula, and from the results of these calculations it immediately became evident that it was impossible to use discharge pipes of the diameters called for by this formula, as they were large.

The committee then decided to make a safety valve discharging into a pipe where the pressure might accumulate at the maximum discharge to 0.585 the entrance pressure, or, with 275 lb. gage entrance pressure, to 154 lb. gage. As the weight passing through the valve or through an orifice is just the same in amount with 154 lb. as back-pressure as with atmospheric pressure as back-pressure, the entrance pressure in each case being 275 lb., the size of the valve need not be increased and the discharge pipe conveying the gases may be made smaller. In such a valve the pressure

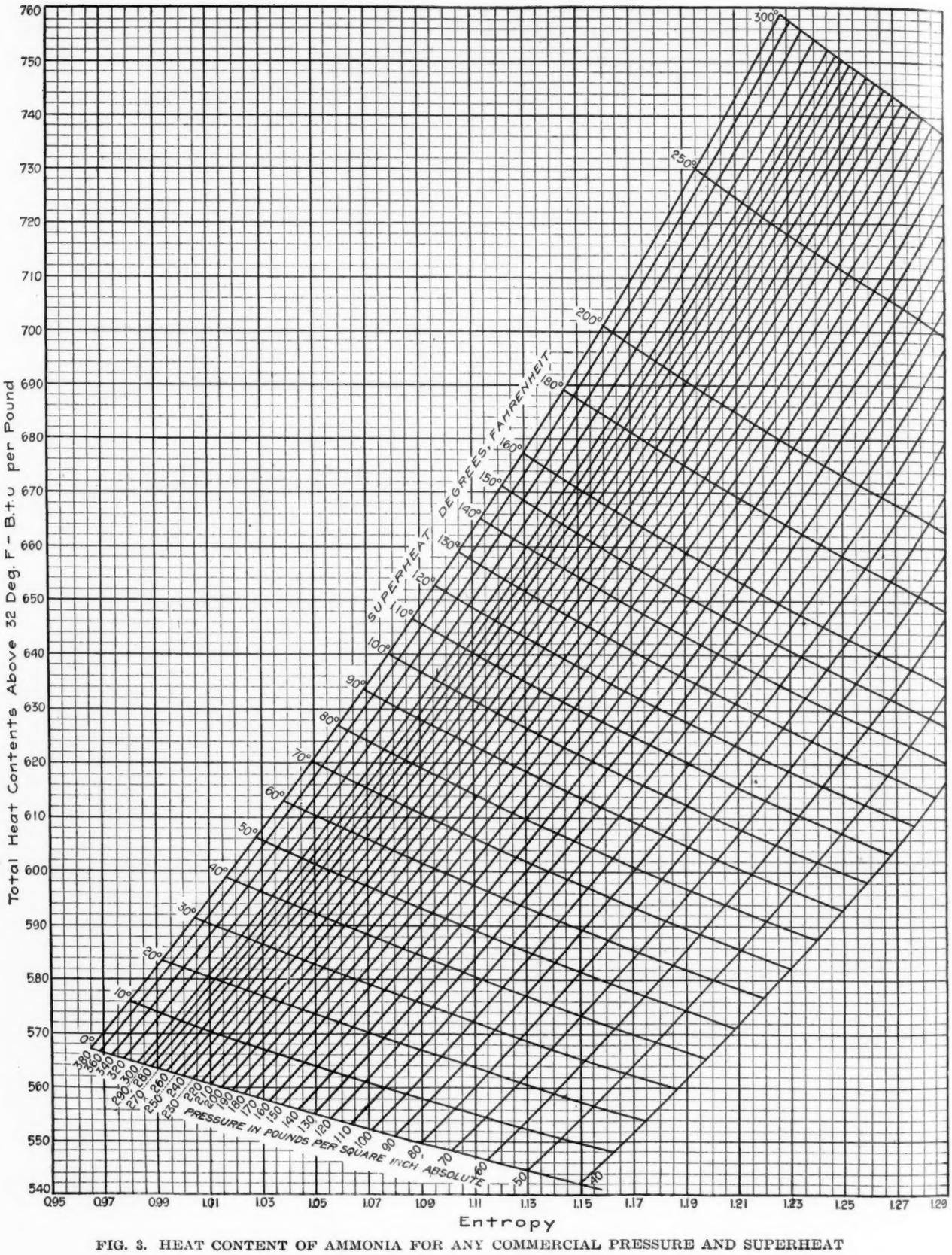



FIG. 3. HEAT CONTENT OF AMMONIA FOR ANY COMMERCIAL PRESSURE AND SUPERHEAT

must be kept from acting on the back of the valve. Such a valve has been made by Mr. Fairbanks and tested out at the Quincy Market company's plant.[1] The idea has been embodied in a new safety valve which was found on test to work satisfactorily.

[1]See "Power," Nov. 30, 1915, for complete description of this valve and for Ammonia Safety Regulations of Massachusetts.

The committee found no available data from which to calculate the diameter of a pipe of given length which is to discharge a given weight of gas per minute entering at 154 lb. and leaving at atmospheric pressure. A run of piping was provided in the Quincy market plant, and a straight run of 200 ft. was installed at the Massachusetts Institute of Technology, and a known weight of saturated steam at high pressure sent into one end, the other being open.

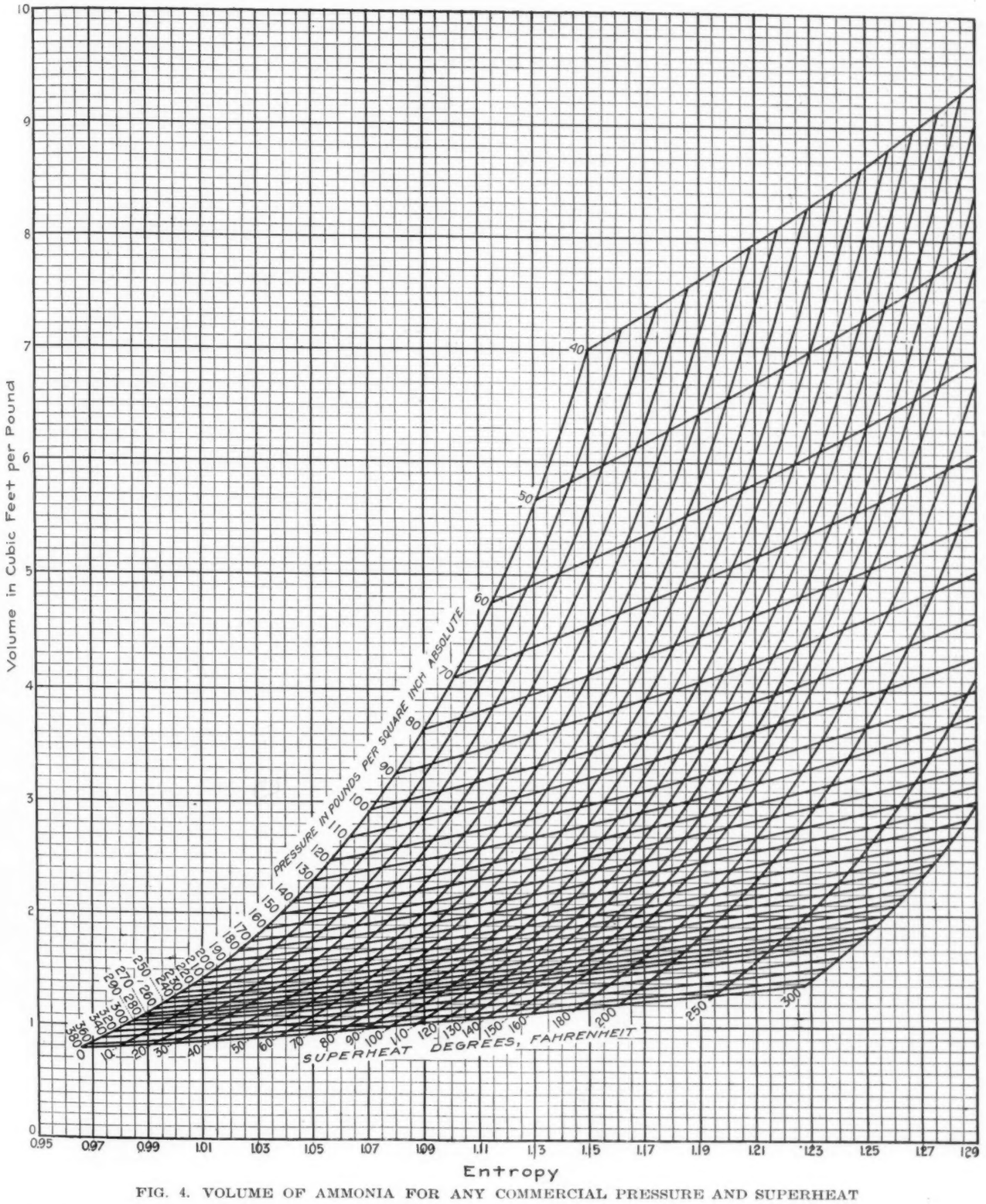



FIG. 4. VOLUME OF AMMONIA FOR ANY COMMERCIAL PRESSURE AND SUPERHEAT

Sufficient data were obtained from these different experiments to warrant the committee fixing the sizes of the discharge pipes as follows:

| Piston Displacement Cu. Ft. Per Min. | Dia. of Valve, In. | Dia. Discharge Pipe First 100 Ft., In. |
|---|---|---|
| 120 | ½ | 1 |
| 280 | ¾ | 1¼ |
| 510 | 1 | 1½ |
| 830 | 1¼ | 2 |
| 1,200 | 1½ | 2½ |
| 2,120 | 2 | 3 |

For the second 100 ft. the pipe should increase one pipe diameter and so on for each additional 100 ft. Pipe bent to a radius at least as great as five diameters is to be used when necessary to turn a corner.

A number of commercial ammonia safety valves were tested by the committee; some were unreliable in their action.

On Feb. 26, 1915, experiments were made with a head pressure varying from 200 to 218 lb. abs., 100 deg. F. superheat, on an orifice 1.045 in. diameter in a plate ¾ in. thick. The entrance to the orifice was rounded to a smooth curve of ¼-in. radius. The pressure in the orifice was taken through a hole $\frac{1}{32}$ in. diameter drilled at right angles to the surface of the straight part of the orifice at a distance of ¼ in. from the exit edge.

The ratio of orifice pressure to head (both abs.) was 0.362. This same orifice was then drilled so that the pressure could be measured $\frac{1}{16}$ in. from the entrance face. The ratio of orifice pressure to head pressure was 0.40.

On Mar. 11, 1915, an orifice 1 in. diameter in a plate 1½ in. thick was tried. This orifice was made with a smooth curve at entrance, of ½-in. radius. The pressure in the orifice was taken through a hole $\frac{1}{32}$ in. diameter located $\frac{33}{64}$ in. from the entrance face. The straight part of the orifice was 1 in. long. The pressure at entrance was varied from 84 lb. abs. to 178 lb. abs. and the superheat from 118 to 160 deg. F. The ratio of orifice to head pressure, taking averages of all the readings, was 0.572. If the two last readings were omitted (these evidently being in error) the average ratio becomes 0.575.

On Mar. 16, 1915, experiments were made on an orifice 1 in. diameter, 2 in. face to face of flange, with curve of ¼-in. radius at the entrance end and with orifice pressure measured $\frac{9}{32}$ in. from the entrance end. This orifice gave a ratio of orifice pressure to head pressure of 0.475. The orifice was then changed so as to have the curve at entrance ¾-in. radius, leaving the straight part of the bore 1¼ in. long. The pressure in the orifice was taken through a hole $\frac{1}{32}$ in. diameter drilled at right angles to the bore and $\frac{25}{32}$ in. from the entrance face. The ratio of orifice pressure to entrance, or head, pressure was 0.585. These tests were made with head pressure varying from 84 to 180 lb. abs. and with from 85 to 1,180 deg. F. superheat.

On this date another orifice was tried. This orifice was 2 in. face to face of flange, with 1-in. diameter hole, having an entrance curve of ½-in. radius. Pressures in the orifice were then taken at four different places—$\frac{17}{32}$ in. back from the front face, ⅜ in., ⅝ in. and 1 in. from the back face. The pressures read from the opening ⅜ in. in from the back face were from 1 to 2 lb. lower than the readings taken from the other places. The readings taken from the other openings were closely alike. The ratio of throat pressure to head pressure, using the readings of throat pressure taken $\frac{17}{32}$ in. in from the front face, was 0.585.

It would seem from the results of these tests that the radius of the curve at the entrance end should be at least one-half the diameter of the orifice and that the straight part of the orifice should be one and one-half times the diameter.

With such an orifice the absolute pressure in it may be assumed to be 0.585 of the absolute pressure at the entrance end, provided the back pressure is not greater than 0.585 times the head-pressure.

If the back pressure in the orifice is above this, then the pressure in the orifice may be assumed to be a slight amount, perhaps 1 lb. above the back pressure.

The weight going through the orifice may be calculated by the following formula, where the letters represent:

V = Velocity in feet per second;
a = Area of orifice in square inches divided by 144, or the area of orifice in square feet;
Z = Volume of one pound of ammonia gas at the pressure and condition in the orifice;
He = Heat content of one pound ammonia at head pressure, B.t.u.;
Ho = Heat content of one pound ammonia at orifice pressure and condition.

$$V = 224\sqrt{He - Ho}$$

$$Wt = \frac{V \times a}{Z}$$

The condition in the orifice is found by assuming an adiabatic expansion from head pressure and condition to orifice pressure.

To save interpolation in Goodenough and Mosher's tables, two plots, Figs. 3 and 4, have been found useful. Fig. 3 gives the heat content for any pressure and number of degrees superheat, and Fig. 4 gives the volume for any pressure and superheat.

Knowing the head pressure and the degrees of superheat, the heat content can be read. The entropy is noted. Following down at constant entropy to the pressure in the orifice, the heat content may be read, also the number of degrees the steam in the orifice is superheated.

On Fig. 4 follow up on the same entropy to the pressure in the orifice and Z, the volume of a pound of gas at the condition of the orifice, may be read.

A simple formula giving results approximately correct for head pressure over 150 lb. abs., when the back pressure is not over 0.585 the head pressure in pounds absolute is as follows:

$$\text{Wt. per sec.} = \frac{0.4 \text{ area orifice in sq.in.} \times \text{Head Pressure lb. abs.}}{\sqrt{460 + \text{temperature deg. F.}}}$$

# Insuring the Coal Supply--II*

By Henry J. Edsall†

*SYNOPSIS—Continues the description of apparatus for stocking and reclaiming coal from storage, begun in the Dec. 14 issue.*

In many, and probably most cases, where railroad trestles are built for storing coal, a better and less-expensive arrangement could be obtained by having the railroad track at ground level and using conveyors to elevate and distribute the coal; and where an overhead supply is desired, the conveyors can usually be arranged to transfer the reserve coal to the overhead bins. A case where the design was changed from a railroad trestle to a conveyor arrangement is shown in Fig. 11.

The railroad track comes in at a level considerably above the boiler-room floor and the coal-storage area, and it was the intention to continue the track out on a trestle so that the coal could be dropped underneath for the reserve storage and delivered to a conveyor arrangement which would deposit it in a bin in the boiler room for the supply to mechanical stokers.

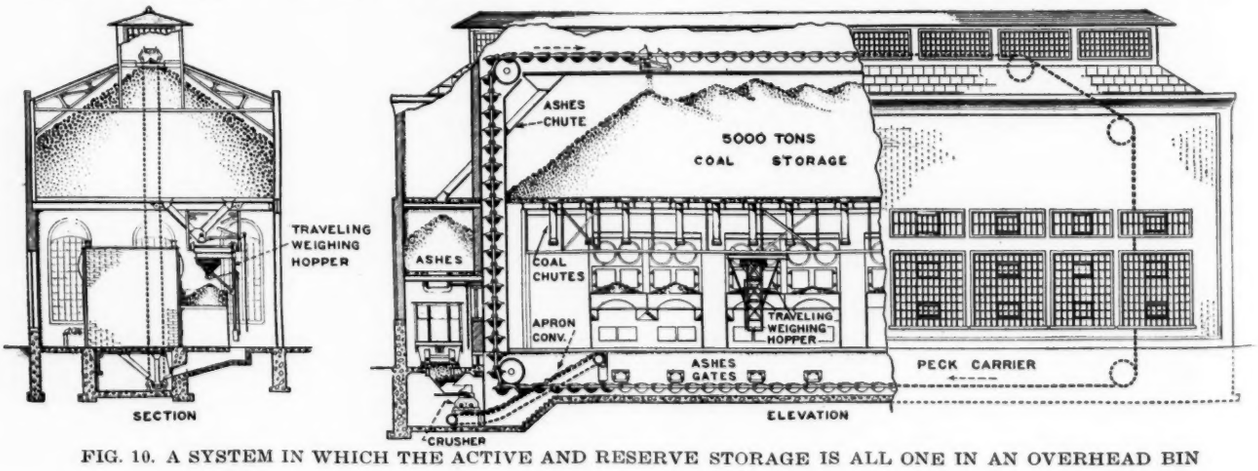
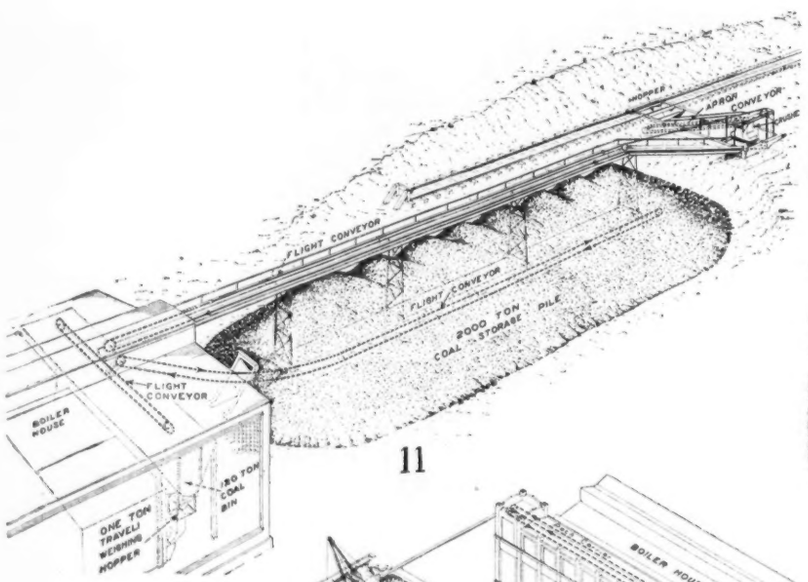



FIG. 10. A SYSTEM IN WHICH THE ACTIVE AND RESERVE STORAGE IS ALL ONE IN AN OVERHEAD BIN

It was found, however, on further investigation, that the conveyor arrangement illustrated in Fig. 11 would be cheaper in first cost and would handle the coal more automatically so that there would be less labor cost, and the amount of

*Reprinted from "Coal Age," Nov. 6, 1915.
†Link-Belt Co., Philadelphia, Penn.

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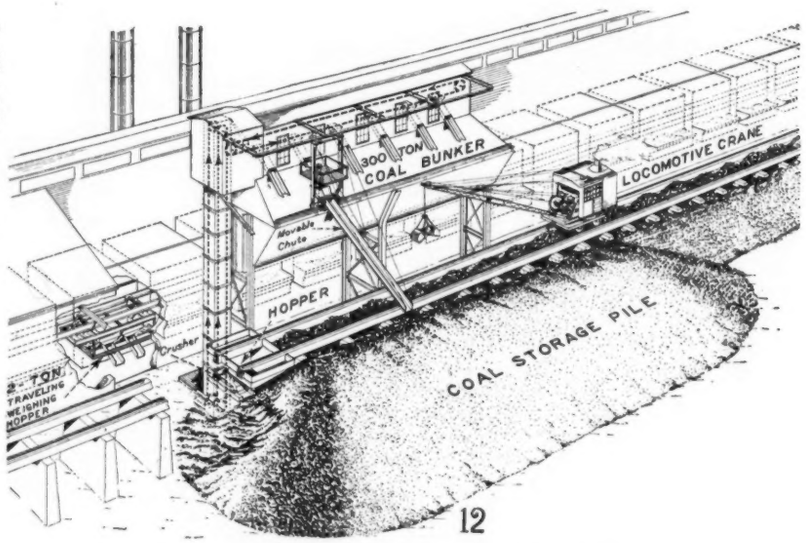


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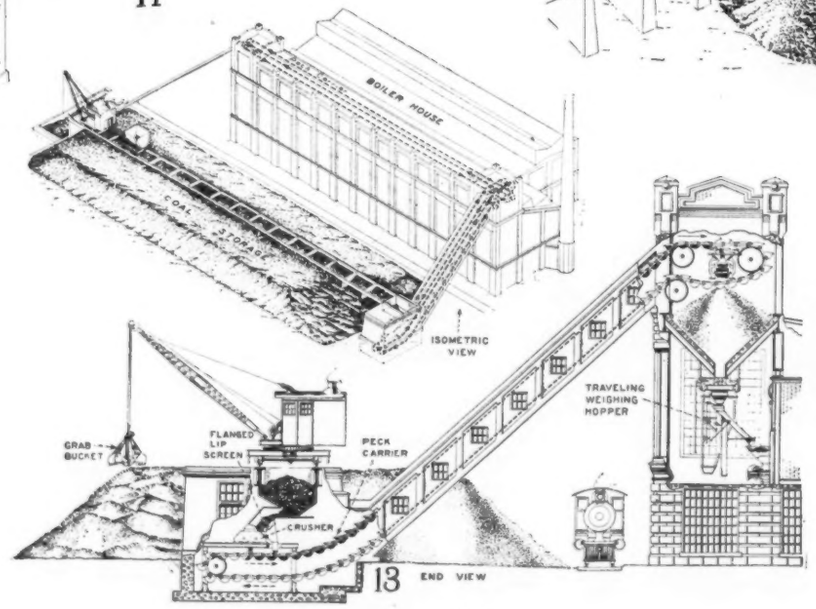


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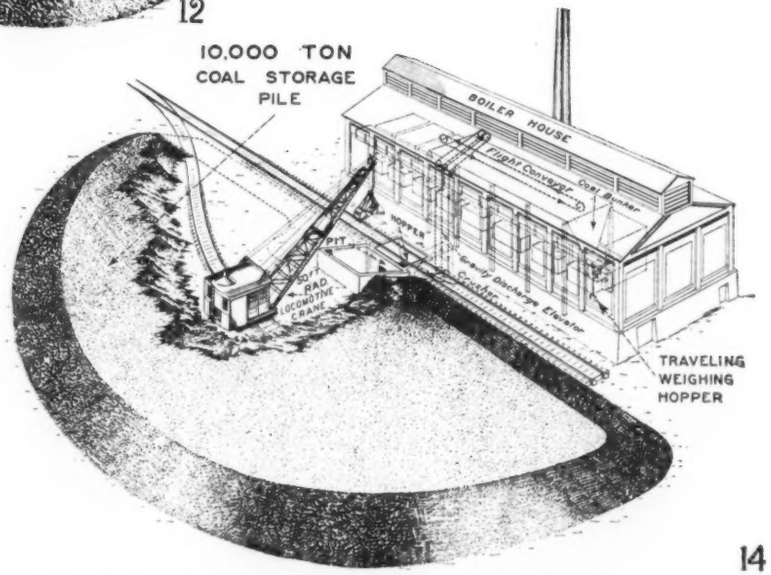


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FIG. 11. FLIGHT CONVEYOR IN PLACE OF RAILROAD TRESTLE FIG. 12. TRAVELING WEIGHING HOPPER USED WITH OUTSIDE STORAGE
FIG. 13. ISOMETRIC AND END VIEWS OF STORAGE ON WATERFRONT FIG. 14. RESERVE STORAGE SERVED BY LOCOMOTIVE CRANE

storage was also largely increased over that which could be conveniently obtained with the trestle. The distributing conveyor takes the coal out along the light trestle and delivers it to the ground storage or takes it directly into the boiler room and delivers to a conveyor over the overhead bin. A feeder is provided at the track hopper to feed the coal regularly to the distributing conveyor, and provision is also made for a possible future crusher installation, though for the present it is intended to purchase coal already sized.

Under the coal pile is a concrete tunnel with a reclaiming conveyor to which the reserve coal can be fed and taken up to the conveyor over the boiler-room bin. The delivery from the overhead bin to each of the three mechanical stokers includes an automatic weighing hopper which will automatically weigh all the coal that is delivered to each boiler. The capacity of the overhead bin in the boiler room is about 120 tons, and about 2,000 tons can be stored in the outside reserve storage. The daily coal consumption of the plant is about 60 or 70 tons.

In Fig. 10 is illustrated what might be called a combination active and reserve storage all in one, since the overhead bin is made very large instead of putting part of the coal in an outside reserve pile. This is expensive construction, but here appearance was an important consideration, and an outside coal pile would have been considered unsightly.

The overhead bin is really a large room on the second floor, extending the full width of the boiler room. It will hold in the neighborhood of 5,000 tons of coal. The amount consumed per day is about 60 tons, so that the storage should last nearly 80 days. While this coal is all stored overhead, on account of the large area of the bin there would be a considerable percentage of it that would not flow out of the chutes without being trimmed over to them by hand.

There is also the danger of spontaneous combustion with such a large and deep pile, and steam pipes have been built into the coal bin so that live steam can be discharged into the coal pile in case of fire, though the effectiveness of this method of providing against fire has yet to be proved.

Both the coal and ashes are handled by a single pivoted bucket carrier, with a feeder and crusher at the track hopper, so that the machinery arrangement is about as simple and ideal as it is possible to make it. The handling of the ashes and feeding them to the conveyor are all done in the basement, so that the dirt and confusion of this operation are avoided on the boiler-room floor. This secures about as neat and shipshape a boiler room as it is possible to get.

Coming now to the equipment, which includes a self-filling bucket for handling the reserve coal, Figs. 12, 13 and 14 show boiler rooms with overhead bins and traveling weighing hoppers for handling the coal. Fig. 12 has the bin outside the boiler room, with chutes through the wall to a 2-ton weighing hopper. As the coal is unloaded from railroad cars it is passed through a crusher and then taken up to the distributing conveyor over the bin by a double-strand bucket elevator.

The distributing conveyor delivers either direct to the overhead bin or to a traveling chute which can be moved along the roof of the bin and which discharges the coal into a pile along the railroad trestle. When the reserve coal in the outside storage is to be reclaimed, this is done by a clamshell bucket on a standard-gage locomotive crane, the coal being picked up and delivered to the track hopper for transfer to the overhead bin. Fig. 13 shows a storage on a water-front property, the coal being unloaded from boats by a locomotive crane equipped with a clamshell bucket and then transferred by a weighing car, or larry, which is pushed by the crane, the car delivering either to the outside storage or to a track hopper for transfer to the bin in the boiler room.

From the track hopper the coal is fed by a reciprocating feeder to a crusher, and then goes to a pivoted bucket carrier which runs up an incline and delivers to another pivoted bucket carrier that distributes the coal in the overhead bin. The weighing hopper in the boiler room has a platform near the floor upon which the operator can ride, but which is near enough to the floor so that he can easily get up and down any time he wishes.

Fig. 14 shows an outside reserve storage served by a locomotive crane traveling on a circular track. When the coal is unloaded from the railroad cars, it either goes through a crusher and up into the overhead bin in the boiler room or into a pit alongside the track hopper, from which the clamshell bucket picks it up and delivers it to the outside pile. When it is being reclaimed, it is handled from the pile back to the track hopper and up into the bin. This makes an excellent type of locomotive-crane storage.

Fig. 15 shows the possibility of using a locomotive crane on a track along a wharf and piling the coal directly back of the railroad track as it is unloaded from boats. In this case there is a conveyor to the boiler room at one end of the storage area, and the coal is either taken out of the boats and delivered directly to the receiving hopper for the conveyor, or if it comes from the storage it is picked up from the area near the receiving hopper and delivered to it without moving the crane, or if this area is all cleaned up, as is frequently the case, the crane takes the coal from farther along the wharf and travels with it to the receiving hopper.

FIG. 15. LOCOMOTIVE CRANE ON TRACK WHARF PILING COAL DIRECTLY BACK OF RAILROAD TRACK

This is not such a slow operation as it might seem, as the crane has a traveling speed of from 400 to 500 ft. per min., so that it can go 200 ft. down the wharf and back in a minute or less; and with this as an average length of travel, a rate of 30 tons per hr. could easily be obtained with a 1-ton bucket.

When a large storage capacity for soft coal is desired, say over 5,000 or 10,000 tons, the cheapest way is to use a large radius locomotive crane and store the coal in a circular pile, as in Fig. 16. This shows a crane with 100-ft. radius traveling on a double circular track with 20 ft. from center to center of the two tracks. With one circular track for the crane and a pit at the center for the buckets to take the coal from, it is possible by this method to store over 70,000 tons of coal. The buckets ordinarily used with a crane of this size will hold 3½ tons, and handling-capacities as high as 240 tons per hr. have been obtained with them.

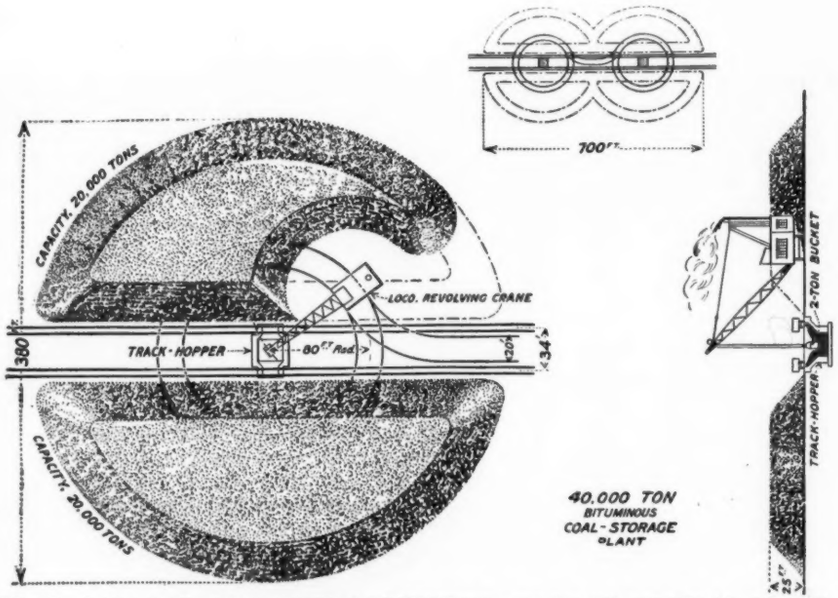



FIG. 16. LARGE STORAGE WITH LOCOMOTIVE CRANE ON CIRCULAR TRACK

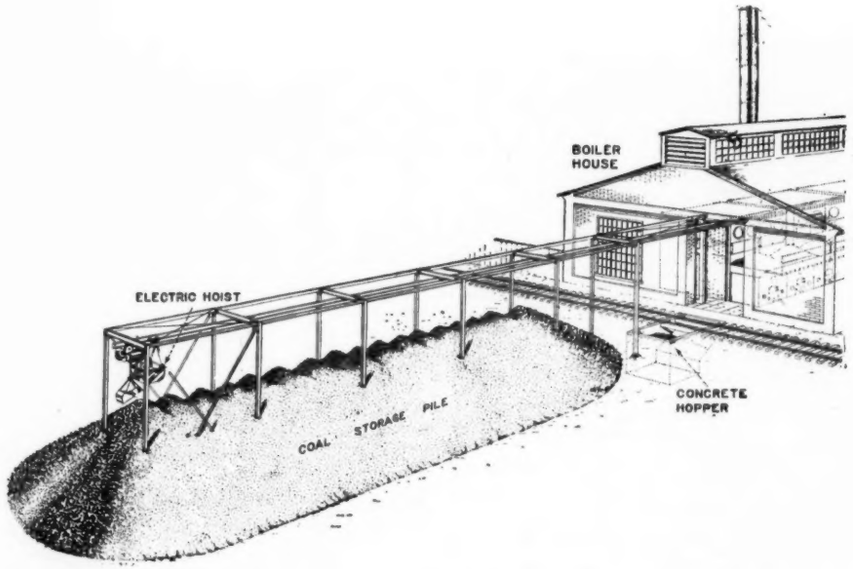



FIG. 17. CLAMSHELL BUCKET ON OVERHEAD MONORAIL ELECTRIC HOIST

FIG. 18. STORAGE PLANT OF NEW YORK EDISON CO. AT SHADYSIDE, N. J.

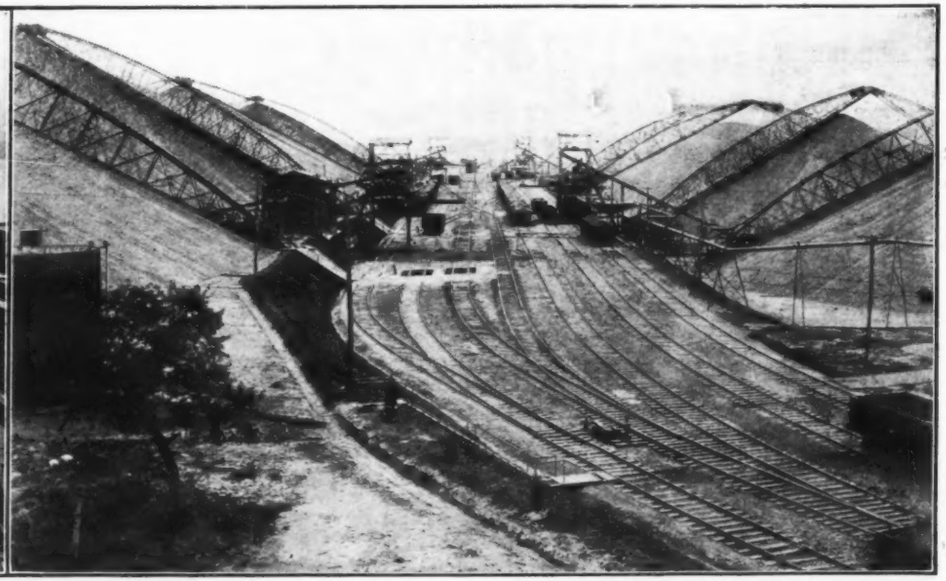


FIG. 19. STORAGE PLANT OF PHILADELPHIA & READING COAL AND IRON CO.

Clamshell buckets handled by electric hoists running on overhead monorail tracks have been used more or less for storing coal and taking it into the boiler room. Such a machine is shown in Fig. 17. The operator travels along with the electric hoist in a small cage and controls both the hoisting and the traveling motors. The coal is picked up from a pit to which it is discharged from the railroad cars and taken either directly into the boiler room and delivered into the stoker magazines or piled on the ground under the monorail track.

This makes a simple, and usually not very expensive, type of storage and delivery to the boiler room, but it necessitates keeping an operator continuously at work handling the coal, and if there is any trouble with the hoist or the operator is not there all the time it means getting the coal in by hand.

This arrangement also complicates the crushing of the coal if it is to be received as run-of-mine and crushed before it is delivered to the stokers. A crusher can of course be placed under the track hopper, so that the coal will go through it before it goes to the pit and then to the boilers, or to the outside storage, but this necessitates a deep pit unless the local conditions are such that the track is elevated.

The storage plant of the New York Edison Co., at Shadyside, N. J., across from New York City, is shown in Fig. 18. This plant has two 100-ft. radius locomotive cranes and a cable railway for distributing the coal along the length of the plant and taking it back. It also has both unloading and loading machinery for transferring the coal from and to boats. The storage capacity of this plant is 225,000 tons.

For storing sized anthracite on a large scale, a successful method is the "Dodge system," wherein the coal is piled in large conical heaps by conveyors running up inclined trusses, and the reclaiming is done by pivoted conveyors which are swung around at the ground level on circular tracks and take the coal back and deliver it to the railroad cars. The Philadelphia & Reading Coal and Iron Co.'s plant of this type at Bridgeport, Penn., is shown in Fig. 19.

This plant has a capacity of 480,000 tons of coal in eight piles. The capacity of the stocking-out conveyors is 1,800 tons per day of 10 hr., or a total stocking-out capacity of 14,400 tons per day. There are four reloading conveyors with a capacity of 2,500 tons per day each, or a total capacity of 10,000 tons per day.

In designing a reserve-storage plant the local conditions and requirements have to be studied carefully, as each installation is a different problem. There are also almost unlimited combinations of different types of machines to obtain the results desired, so that expert knowledge and long experience are necessary in order to select the type of plant that will give the best satisfaction and prove cheapest.

# Convention of American Society of Mechanical Engineers

More people attended the thirty-sixth annual meeting of the American Society of Mechanical Engineers in New York than any previous meeting in its history. At the close of the convention, which lasted from Dec. 7 to 10, there were registered 1,370 members and guests.

Several of the papers presented were of direct interest to "Power" readers, and some of them have already appeared in these pages, as noted later. The order of program was generally similar to that which was followed in previous years with the exception of Wednesday evening, when, instead of the usual lecture, a smoker was given in the society's rooms, and the departure proved a great success as a means of getting the visiting members better acquainted. The dinner-dance for Thursday evening, inaugurated last year, was repeated with slight modifications.

The entertainment provided in the way of excursions again followed the experiment, so successful last year, of reducing the number of attractions so that there might be the benefits that usually attend excursions in which a goodly number participate. The excursions were carefully selected to cover widely diversified interests, and their popularity was attested by the large attendance. The program consisted of a trip to the Vitagraph Company of America, where an opportunity was afforded of witnessing the production of motion pictures; a visit to the Brooklyn Navy Yard, where the large Diesel engine for the "Maumee" was seen in operation, the turbines for the battleship "Arizona" were viewed in the course of construction, and several vessels were inspected; a trip to the aviation field at Garden City; another to the plant of the Harrolds Motor Car Co., at Long Island City, where Pierce-Arrow trucks and cars are assembled; and visits to the Municipal and Woolworth Buildings, the elevators in these buildings being special features.

The features of the opening session Tuesday evening were the address of the retiring president, Dr. John A. Brashear, on "Science in Its Relation to Engineering," and the introduction of the president-elect, Dr. D. S. Jacobus. Following this function in the auditorium, the annual reception was held in the society's rooms on the eleventh floor of the Engineering Societies Building.

In the following report is included discussion of such papers as have already been abstracted or reprinted in "Power," but discussion of those papers which are to be printed somewhat in full later is withheld to appear with them.

## THE DESIGN OF FIRE-TUBE BOILERS

The Wednesday morning professional session opened with the paper by F. W. Dean, of Boston, on the "Design of Fire-Tube Boilers and Steam Drums," which, in substance, was as follows:

Because the Boiler Code of the Society cannot, in the opinion of Mr. Dean, cause good designing of boilers in all respects, he desired to extend the work of the code by considering those things which make the boilers dangerous and how some parts may be improved in design so as to make boilers safe. He considers design rather than material because he believes that there have been comparatively few boiler explosions caused by inferior material.

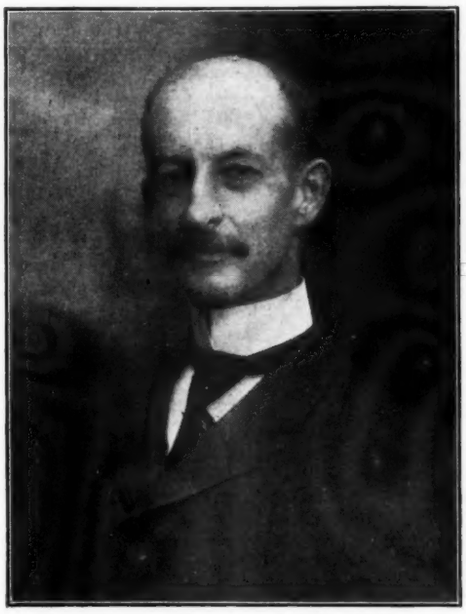
The author merely mentions the formerly common assumption that many steam-boiler explosions were due to the application of comparatively cold water to hot plates, in view of the experiments which have been conducted and which show that a hot plate cannot vaporize enough water to create a dangerously high pressure.

In a general way it can be said that boilers explode because they are not strong enough to stand the pressure to which they are subjected. When boilers are new they are usually strong enough, but in service they weaken. Corrosion sometimes does this, but not often sufficiently to cause an explosion. The great and usual cause of weakness is such a form of some part that with the repeated application and removal of pressure, or with variations in pressure, that part bends first one way and then the other, and this causes cracks. It is in general the shells at the longitudinal joints which act in this way, and it is safe to say that nearly all explosions of fire-tube boilers are caused by the bending and resultant cracking of this part of the shell. Occasionally a boiler corrodes sufficiently to weaken it to the breaking point.

As is generally understood, the most prolific cause of explosions of fire-tube boilers has been lap longitudinal joints, and the use of butt joints with inside and outside covering plates has so far done away with such explosions. The lap joint makes a boiler noncircular at and in the vicinity of the joints, and with the application of pressure, which varies, the boiler tends to return to its original form, causing cracks. There have been cracks in the butt joints of four horizontal return-tubular boilers, and their leakage gave warnings so that the boilers were taken out of service before they exploded. These occurrences are causes for anxiety, for we cannot expect warnings in all cases. It is of importance to design butt joints that will not bend in service. Therefore the defects in these joints as generally used in land boilers in the United States and Canada should be most impressively pointed out. The joint referred to is the one that has a narrow butt strap on one side of the shell and a wide one on the other. This joint is one-sided, and its center of resistance does not coincide with the center of pull of the shell plate. The rivets in the outer part of the joint are overhung and in service tend to tip over and bend the joint. An illustration showing how this type of butt-strap joint bends or distorts in service was shown. The plates and the cover plates tend to become corrugated, with the low point of the corrugation in the center of the outside cover plate and the low point of the next corrugation coming at that point where the inside cover plate ends. To prevent a joint from bending, a butt joint with straps of the same width and with all rivets in double shear should be used, as is always done in Europe. A press should be used to shape the plate, as is done in England, instead of hammering or rolling it to shape.

Boiler-head braces of the crowfoot or similar types are usually designed so thin that they bend in service where the foot joins the rod and are likely to break finally at this joint. Through rods above the tubes of horizontal return-tubular boilers should be supported so that they cannot vibrate, and the support should be stiff enough to prevent movement in any direction instead of merely supporting the weight. If any braces are used below the tubes, through or head-to-head braces rather than braces riveted to the shell should be employed. Such braces should not pass through the back head, on account of the nut being in contact with the fire. The rod should be secured to angles riveted to the back head, but separated from it by 2 to 4 in. by ferrules around the rivets to permit the removal of dirt between the angles and the head.

The author commended the hydraulic riveting machines which, because of the slow movement of the plunger, well fill the rivet holes. It is the common practice in this country to punch holes ⅛ or ¼ in. small and then to drill them to size with all plates in place. This is an advance over punching to size, but it is not satisfying, and it may be one reason why plates exposed to the hottest gases crack between the rivets and their edges. Another reason for such cracking may



DR. D. S. JACOBUS
Newly elected president of A. S. M. E.

be bulging caused by too much pressure by the riveting machine on the rivets. The best way is to drill all holes from the solid, and with proper tools this will probably be found the cheapest method.

Above the stay-bolt level of vertical boilers, the outside fireboxes are subjected to the full stress that comes from the steam pressure, unreduced by any connection to the inside firebox by the stay-bolt. In some designs the whole outside firebox is made of the thickness required to stand the pressure as if unstayed; in other designs there is a short course of increased thickness just above the stay-bolt, and in still another the outside firebox plate is thin for its whole height and is reinforced above the stay-bolt by riveting a band of steel around the inside of the plate. As already stated, shell explosions are nearly always caused by the bending of the plates, and the inside reinforcing plates of vertical boilers can do no good without bending. They cannot prevent the main plates from being overstrained, and are therefore possible causes of explosions.

The author here describes the action in the type of vertical boiler which is changed in diameter above the firebox by means of a reversed flange. On account of the ease with which this flange bends, the boiler elongates when subjected to pressure. Even the pulsations and pressure coming from the opening and closing of the valves of the engines make the boiler change its length each time, causing many of the reversed flanges to crack. The effect has been reduced by making this flange of less flexible form and increasing its thickness. Another harmful effect of the elongation of boilers of this type is the bending of the lower tube plate upward and the upper one downward, tending to pull the outer tube from the tube plate, and this may possibly cause explosion. To obviate the two defects just described, the reduction in diameter should be made by a conical course.

Several explosions have been caused by dished heads cracking along the edges where they join the spherical portion. There is no doubt that such heads breath and that the cracking is due to this. Such heads should be made thinner than usual and braced like flatheads. Radial plate gusset stays would be best for bracing the heads if placed at equal distances completely around the drum. The author favors the front tube plate of horizontal-tubular boilers when flanged forward instead of backward as in the flush-head type and hopes that by careful designing a factor of safety of four, as used in locomotive practice, will some time be used in stationary boilers. Explosions in locomotives are almost exclusively confined to the blowing down of overheated crown-sheets.

The author commends the Woolson method of supporting boilers. (See hanging and setting of horizontal fire-tube boilers by O. C. Woolson, Transactions A. S. M. E., Vol. 19, page 781.) Horizontal return-tubular boilers, no matter what their length or size, should be supported at no more than four points. If boilers are long it is common to support them at six points. To prevent the end supports from leaving their bearings, springs are often placed under the middle bracket, but this does not render the pressure on the supports equal and is only a makeshift. The three point support commended by the author is the Woolson support, in which the boiler is held up at four points; two points at one end are supported in the usual manner, and the other two are connected by links to an equalizing lever working on a pin passing through overhead supporting beams.

In discussing the paper Thomas E. Durban stated that it was his experience that in drilling a number of plates with butt straps it is impossible to drill them through in the solid and make as good a job as when a pilot hole is punched and the drill run through the pilot hole.

## PREVENTING BOILER CORROSION AND SCALE

The next paper was by Allen H. Babcock, of San Francisco, on "A Novel Method of Handling Boilers to Prevent Corrosion and Scale." The paper was read by Frederick E. Giebel in the absence of Mr. Babcock and an abstract of it will soon be published in "Power."

The next two papers, "Gas Producers with Byproduct Recovery," by Arthur H. Lymn, and "Modern Electric Elevator and Elevator Problems," by David Lindquist, were read by title only, both having been previously presented at New York local meetings and passed without further discussion. The second of these was abstracted in "Power," in the issue of May 11, page 656.

The same was true of the papers, "Turbines vs. Engines in Units of Small Capacities," by J. S. Barstow, contributed by the Philadelphia local committee; "The Connors Creek Plant of the Detroit Edison Company," by C. F. Hirshfield, contributed by the Buffalo local committee; and "Proportioning Chimneys on a Gas Basis," by A. L. Meuzin.

The paper on "Higher Steam Pressures," by Robert Cramer, presented Wednesday afternoon in the Textile Session, was published Dec. 7. The most important discussion on this paper follows:

William Kent remarked that taking 225 lb. and 200 deg. superheat, corresponding to a temperature of 591 deg. and a Rankine-cycle efficiency of 33.6 per cent., as about the standard of the most recent practice, the improvement that may be made by using a pressure of 600 lb. and a temperature of 600 deg. is 37.3 — 33.6, or 3.7, or 11 per cent. of 33.6 per cent. To obtain this gain it will be necessary to build stronger boilers than we now have, to use economizers to reduce the flue-gas temperature and to take extra precautions against steam leakage. These improvements are quite within the range of practicability, and it may be worth while to make them to gain 11 per cent. in efficiency, especially where fuel is expensive and in plants that have a high load factor. Mr. Cramer says that it is possible to increase the effectiveness of the heating surface by proper design, and that modern boilers show an evaporation per square foot of heating surface twice as high as was customary only a few years ago, at the same time realizing a better efficiency than formerly. It does not appear that the improvements in rate of driving and in efficiency at high rates of driving have been the result of any changes in the design or proportions of the heating surface; they have been due to greatly enlarged combustion chambers, mechanical stokers and control of the air supply according to the indications of gas analyses. The highest efficiencies have been obtained with many different forms and proportions of boiler, and no evidence has yet been obtained that any new form of boiler will give greater effectiveness than the forms built forty years ago.

R. J. S. Piggott commented on the paper, pointing out in the instance of 200 lb. initial pressure, exhaust pressure 29 in. vacuum, a gain of approximately 15.5 per cent. for operating at 600 lb., with total temperature of about 600 deg. He thought that the sources of loss, friction in the turbine, etc., were passed over perhaps too lightly. Those who have been interested in turbine design for the last few years have noticed the marked difference in the efficiency ratio of the various stages of the turbine, whether they be at the high- or low-pressure end of the machine. The high-pressure stages of the turbine are much less efficient than the low. For instance, a turbine working at 200 lb. with 100 deg. superheat has an efficiency, at the first stage, of possibly 55 or 56 per cent., or a little bit higher, depending upon the condition, this increase toward the lower stages finally reaching 85 per cent. or even more in reaction turbines. The average of the turbine is 70. The actual efficiency of the Interborough turbines is over 80 per cent.; if one discounts the losses to the generator, the actual ratio is 80 per cent. overall, representing a high-pressure efficiency of 70 per cent. and on the final stages, somewhat over 90 per cent. The efficiency of the stages is dependent chiefly upon the density and condition of the steam. Such low efficiencies in the high-pressure stages are on account of the high friction losses due to high steam density; and in turbines running on saturated steam, and on account of the additional friction due to the moisture, it is certain that as the pressure is increased, the high-pressure stages will become less efficient—more especially as in substituting pressure for superheat we are increasing the amount of moisture to be contained in the turbine and leaving the dew point further up in the stages. In other words, the efficiency of each stage is going to be somewhat decreased, owing to the presence of a greater quantity of moisture. Mr. Cramer's expectations of the efficiency closely approximating present efficiency, he thought would not be quite reached. It would be difficult indeed to make the efficiency at the stage working on 600 lb. with 100 deg. superheat equal to that of a stage working on 200 lb., with possibly 200 or 250 deg. superheat. Another question from the practical side is that of the piping and pipe joints. Some have had success with ground joints, but the character of workmanship and pipe construction required of the ground joint is almost too high for ordinary construction in the average plant. So forms that require, say, metallic or asbestos or other soft gaskets have to be used for these temperatures and pressures, and there is trouble enough now with 200 lb. The present pipe joint is by no means everlasting. With 600 lb. there will probably be considerably more difficulty in maintaining pipe lines. At a Western plant—the Detroit Edison or the Commonwealth—it is reported that the engineers are fusing the edges of the flanges with the acetylene torch to avoid the question of gaskets. This seems to be the first step in the change that would be required for very high pressures. The next step would be to abandon flanges and weld the pipes in place, doing away with joints.

G. I. Rockwood predicted that the practical requirements of pipes built in sections rather than welded together will call for pipe unions made so that any pressure can be maintained.

## HIGH TEMPERATURES WEAKEN MATERIALS

R. H. Rice said that in seeking the materials to be used for these high pressures and temperatures, it is found that at 600 deg. F. practically all of the materials that would be used in the construction of such apparatus begin to lose strength. Therefore one must be careful not to exceed that temperature, or one would have to be critical in the choice of special materials for the construction of such apparatus, or else (the third possibility) one would have greatly to increase the thicknesses and dimensions to keep down the stresses per unit of area. The question of expansion in pipes is also one that would be troublesome, on account of their extreme thickness. There would be powerful thrust with such expansion and contraction. Additional difficulty is leakage; if we attempt to use very high pressures on the upper stages, we will certainly have to develop improved forms of vacuum. The speaker believes that at present we are fitted to undertake the development of apparatus to meet these conditions; but considerable development work will be necessary, and in the course of it we will find that the new conditions will give rise to considerable changes in the designs of our power stations. For instance, it is obvious that if these expansion stresses are to be difficult, we should limit the pipe to the maximum possible extent, and this indicates very close relationship between the boiler and turbine, or the engine, as the case may be. He is optimistic as to the possibilities, but the question is a commercial one. Assuming that these gains or even half of them can be realized, can apparatus be constructed of such cost and placed in power stations under operating conditions that will involve operating expenses in such amounts that the total operating gain, counting interest on the investment, operating cost and general liability, will make the proposition a profitable one?

Walter N. Polakov remarked that European practice does not confine itself to 600 deg. F., but goes up to 800, and said he knew of two cases where 1,000 deg. is used.

Dr. D. S. Jacobus called attention to the statement that standard boiler designs do not permit the construction for steam higher than a pressure of 200 lb. That is a little below the limit, because there are standard designs operating at high overloads and using 300 lb.

Two other papers at this session are to be printed later: "Heating by Forced Circulation of Hot Water in Textile Mills," by Albert G. Duncan; and "Relative Value of Private and Purchased Electric Power for Textile Mills," by Frank W. Reynolds and Dan Adams.

Simultaneously, Wednesday afternoon there were held Machine-Shop and Railroad Sessions. There was also a reception and tea at 3 p.m. in the Society's rooms, given by the Ladies' Committee. The smoker before mentioned was held in the evening.

Thursday morning there were two simultaneous sessions, at one of which, the Power-Plant Session, several papers of interest to this field were presented. Those to be printed later in these pages include "The Heat Insulating Properties of Commercial Steam-Pipe Covering," by L. B. McMillan; "Circulation in Horizontal Water-Tube Boilers," by Paul A. Bancel; and "Unique Hydraulic Power Plant at the Henry Ford Farms," by Mark A. Replogle.

## HIGH-VACUUM SURFACE CONDENSERS

Another paper at this session was "Performance and Design of High-Vacuum Surface Condensers," by George H. Gibson and Paul A. Bencel. This pointed out that the coefficients of heat transmission secured in commercial condensers are far short of those realized in experimental laboratory condensers, and moreover, the coefficients obtained under summer conditions are always better than those obtained from the same condensers in winter, with colder circulating water. Examination of a number of tests of condensers with varying conditions shows that the depression of the air-pump suction temperature below the steam temperature corresponding to the vacuum is related to the average coefficient of transmission or relative proportion of the active zone of condensation, in a definite way. This depression is due partly to a fall in pressure and expansion of the steam incidental to its flow through the resistance presented by the condenser, and is also implied in the increasing partial pressure of the air as the latter nears the air-pump suction opening.

If the pressure at the inlet of the condenser is known and the drop can be calculated, the pressure at the air-pump suction can be predetermined; and taking into consideration the fact that the virtual displacement of the air pump is approximately constant and that the air must therefore be reduced to a fixed volume regardless of vacuum, the temperature of the air-pump suction with a given amount of air can be calculated. This, in connection with the inlet-steam temperature, is an indication of the average coefficient of transmission to be expected, which in turn makes it possible to estimate what water temperature will be necessary in order to carry the same load at a different vacuum, or vice versa. For a given condenser the effects of changes in load, vacuum, water temperature, rate of flow and air-pump capacity can be foretold if its performance under one set of conditions is known.

At high vacuums the spacing and the number of rows of tubes, which determine the pneumatic resistance of the steam-flow path or paths, have great influence upon the average efficiency of the surface in transmitting heat. Since the controlling resistance is on the air-steam side of the tubes in the air-drowned inactive zone of the condenser, increase in water velocity is of little benefit in these tubes. In fact, this velocity may be decreased and the velocity in the tubes of the active zone increased, where it will do some good without added power expenditure. Zone condensers of this kind were illustrated.

At the Miscellaneous Session the first paper was on "The Flow of Air Through Thin-Plate Orifices," by Ernest O. Hickstein. This paper, which described the methods used by a large pipe-line company in the mid-continental field in calibrating its orifice-meter disks, had the distinction of having won the Junior Prize offered by the society for 1915. It deduced the following general formula for the flow of air through an orifice disk.

$$Q_o = C_a \sqrt{h P_1}$$

where

$Q_0$ = Volume at standard temperature and pressure;
$C_a$ = So-called "gas constant" found experimentally;
$h$ = Differential in inches of water;
$P_1$ = Pressure at inlet of orifice.

It then described in detail tests made at Joplin, Mo., to determine the velocity coefficients of 8- and 10-in. orifice meters. The disks were calibrated against the displacement of air from an old artificial gas holder with a lower lift capacity of 110,000 cu.ft. Preliminary tests were run to determine leakage from the holder and changes of volume in the holder with temperature variation. About 160 tests were then run on 8- and 10-in. meters; a summary of the results was given in the paper.

The final paper of this session was "Oil-Engine Vaporizer Proportions," by Louis Illmer. This dealt with some researches to determine the proper proportions of hot-bulbs for oil engines of the Hornsby-Akroyd type, and extended to include high-compression oil-engine vaporizers.

The vaporizer of low-compression oil engines is heated by the gases of combustion and provides a hot surface for the double purpose of evaporating the heavy mineral oils in the fuel oil and of maintaining the confined mixture charge at a temperature high enough to enable self-ignition to be induced. The one simple relation suitable for design purposes is that of vaporizer volume to piston displacement. The other design factors depend upon more involved relations and center about the average temperature attained by the unjacketed cap portion of the vaporizer wall. By analysis the average full-load cap temperature of a Hornsby-Akroyd engine is found to be about 1,275 deg. F. The total vaporizer volume should be about 0.3 of the piston displacement, or about two-thirds the clearance volume.

When such an engine is running on ¼ to ½ of the full-load oil, the hot products of combustion may be expected to raise the temperature of the entire vaporizer content to 750 deg. F. ignition temperature. Below this critical point the temperature head is reduced to such an extent that the cap no longer keeps the vaporizer content sufficiently preheated to reach the ignition temperature at the end of the compression temperature. The limit of efficiency and mean effective pressure of the engine are so restricted as to make it quite cumbersome in sizes of 50 b.hp. and upward. This limitation may be overcome by injecting the fuel oil, by means of highly compressed air, near the end of the compression stroke.

Oil engines operating at less than 135 lb. per sq.in. compression pressure should have their vaporizer volume made equal to the entire clearance space, while in high-compression engines the vaporizer volume may be made proportionally smaller; at about 400 lb. compression pressure the vaporizer may be dispensed with. The moderate preheating requirements of the high-compression engine allow self-ignition to be attained without maintaining the vaporizer cap at full-red heat; this reduces internal strains in the cap casting.

Thursday evening the annual reunion dinner and dance at the Hotel Astor was a complete success and well attended.

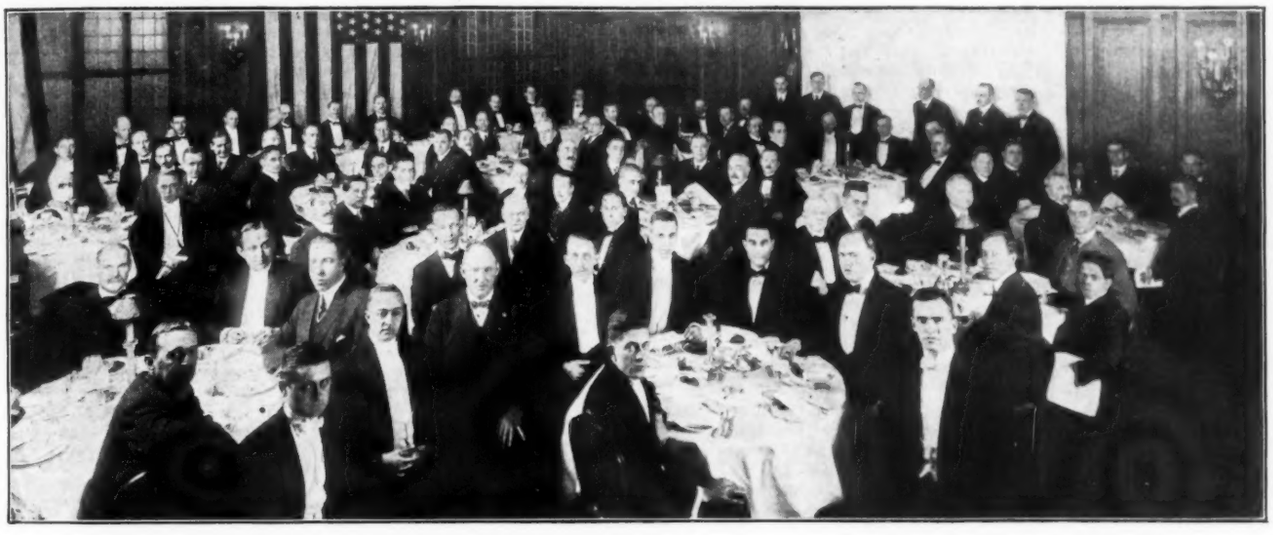
At the last professional session, held Friday morning, there was a symposium of papers on industrial safety, but nothing of special interest to the power-plant field.

# Meeting of American Society of Refrigerating Engineers

In every way, but particularly in the papers presented, the annual meeting of the American Society of Refrigerating Engineers, held at the Engineering Societies Building, New York, Dec. 6 to 8, was the most successful of any in the 11 years of the society's history. Monday morning was devoted to business and to the address of the retiring president, Louis K. Doelling.

After a complimentary luncheon at the Engineers' Club, Prof. Edward F. Miller, of the Massachusetts Institute of Technology, Boston, read a paper on the flow of ammonia through orifices. This paper was particularly interesting because it dealt with the technical side of experiments made preparatory to formulating the ammonia safety rules of Massachusetts. The experiments brought out the interesting fact that a true Napier orifice must have its entering edges rounded to a radius of at least one-half the diameter to obtain 0.585 of the initial pressure at the outlet side of the orifice. An abstract of Professor Miller's paper appears in this issue.

The paper by F. L. Fairbanks, of Boston, on the "Quincy Market Safety Valve for Ammonia," followed. Mr. Fairbanks described the valve, which was designed to comply with the Massachusetts ammonia rules; the rules were also read. Considerable interest was centered in this paper and the rules, for the reason that no other safety valve for ammonia is acceptable to Massachusetts.



AMERICAN SOCIETY OF REFRIGERATING ENGINEERS AT BANQUET IN THE HOTEL MARTINIQUE

Some of those present were chagrined because they considered that, as no other valve was acceptable, a monopoly existed. The tension in this direction was eased, however, when Mr. Fairbanks explained that the valve was not patented, that every metal of which it is composed is stated, and that a sectional view and dimensions are given in the illustration which appears in the rules book as issued by Massachusetts. Of course any valve that will perform the functions prescribed in the rules is acceptable.

There seemed to be a misunderstanding on the part of some present as to who drew up the rules. At the meeting of the society a year ago, a committee was appointed to cooperate with the Fire Prevention Bureau of the New York City Fire Department, which was then drawing up ammonia rules for New York City. Later a subcommittee for Boston was appointed. It seemed to be understood by some that this subcommittee drew up the Massachusetts rules, and when it was learned that they did not, dissatisfaction was expressed that the rules should have been drawn up without the rules committee being given ample opportunity to coöperate and approve. Mr. Fairbanks replied that the committee had had ample opportunity, as the rules had been a year and a half in preparation, and that notices of public hearings on them had been given by the Board of Boiler Rules of the state. When the committee did appear it was too late, as the rules as prepared had then been accepted.

The committee on rules did not report at this, the eleventh annual meeting of the society.

It was explained at the meeting that the Massachusetts law authorizing the Board of Boiler Rules to create and en-

force ammonia safety rules does not apply to the absorption system of refrigeration or to refrigerants other than ammonia. Mr. Fairbanks intimated, however, that the law would likely soon be amended to include the absorption system.

Following Mr. Fairbanks, Prof. G. H. Clark, of the Massachusetts Institute of Technology, read a paper describing an experimental type of safety valve which aims to perform the high discharge function of the type of valve recently used by the British Admiralty on torpedo boats and also of the valve designed by Mr. Fairbanks. An abstract of Professor Clark's paper will be printed in a later issue of "Power."

Monday evening's session may well be called the Bureau of Standards session, as Dr. H. C. Dickinson, of the bureau, read two papers—one on "The Testing of Thermal Insulators" and one on "Work of the Bureau of Standards on Constants of Refrigeration." D. C. Harper, of the bureau, read a very technical paper dealing with preliminary measurements of the specific volume of anhydrous ammonia.

Tuesday morning's session opened with a paper by John E. Starr, consulting engineer, New York City, dealing with the moral obligations of engineers and manufacturers toward the society. Peter Neff, well known in refrigeration circles, followed with a paper on the status of refrigeration in breweries, in which he said that, though many breweries were working below rated capacities and therefore refrigeration costs in them were high, worth-while savings were possible in many ways; it remains for the engineer to point out these to the owners. Closer attention to losses through imperfect or inadequate insulation; the removal (or covering) of steam piping, pumps or other steam machinery from refrigerated rooms; ventilation of fermenting rooms; indirect refrigeration; reduction of operating costs by running some of the machinery at full load instead of many machines each lightly loaded; utilization where possible of the ice on the coils to supply refrigeration during the night or on Sundays—these are some of the channels through which saving may be effected.

Much discussion was had on a paper on boiler-room economies, by F. E. Matthews. Mr. Matthews' paper will appear later in "Power."

In the absence of Prof. J. A. Moyer, of the Pennsylvania State College, his paper on the "Effect of Velocity and Humidity of Air on the Heat Transmission Through Buildings" was read by Charles Herter. Dr. Frederick Keyes, of Hoboken, N. J., read a paper on equations for ammonia based on recent experiments of his own and others. An abstract of this paper will appear later in "Power." In commenting on Doctor Keyes' paper and on the work of the Bureau of Standards, Professor Mosher stated that his tables of the properties of ammonia were intended to meet the demand for greater accuracy than could be had with the older tables and to make this greater accuracy available until the work now being carried on by the bureau would make possible the development of still greater accuracy. A paper on the "Steam Economy of an Absorption Refrigeration Machine" was read by Clarence W. Vogt, of Louisville, Ky.

On Wednesday morning S. J. Dennis, of the United States Department of Agriculture, read a paper by himself and Professor Mosher on "Temperature of Fruits and Vegetables in Transit in Refrigerator Cars." To those interested in the shipment of refrigerated goods this paper is of much interest. It appears in the November "Journal" of the American Society of Refrigerating Engineers. Messrs. B. H. Coffey and George A. Horne, of New York, presented a paper on "A Theory of Cooling Towers Compared with Results in Practice." The tower referred to is of the atmospheric type. The last paper read at the meeting was one of the most interesting, though it was not strictly one of a refrigeration character. It dealt with corrosion in concrete buildings and in pipe lines and was prepared and read by Morgan B. Smith, of Detroit. Consulting and contracting refrigerating engineers so frequently design the buildings of ice and cold-storage plants (so many of which are now of concrete) that to them the subject is of interest. Some valuable information about electrolysis is to be found in the paper.

The annual dinner was held in the Hotel Martinique, and instead of the usual eloquence two lectures were given, both illustrated—one by Doctor Tolman, director of the American Museum of Safety, on "Safety Pays," and one by W. H. Prentis, Jr., of Pittsburgh, on "The Cork Industry."

Theodore Vilter, of Milwaukee, is the new president of the society.

The amended report of the committee on a standard method for finding the fuel economy of steam-driven ice plants will be published in these pages.

One of the features of the meeting was a report of comparative tests on the old pipe-coil ammonia condenser and the flooded-type condenser, by Henry Torrence and V. R. H. Greene. In view of the fact that so much has been claimed for the flooded-type condenser over the old type, the results obtained by Messrs. Torrence and Greene and checked by Fred Ophüls are interesting because they show no marked advantages for the former. The type of flooded condenser tested was that wherein liquid ammonia is admitted in jet form into the bottom of the condenser. The authors did not attempt to explain the reason for the results they obtained, but presented them so that an explanation might be brought forth during discussion. No satisfactory explanation was given, but the discussion will be continued by those interested.

Last year F. L. Fairbanks presented a paper describing the 1,000-ton compressor of his own design in the plant of the Quincy Market Cold Storage and Warehouse Co., Boston. The compressor uses (or, rather, did use) the multiple-effect compression idea of Gardner Voorhees, wherein two gases of widely different pressures are compressed in one cylinder. Mr. Voorhees criticized parts of the paper. In replying, Mr. Fairbanks stated that as litigation was likely or was pending between his company and Mr. Voorhees, he felt at liberty to say but little. He did say, however, that the 1,000-ton machine could run satisfactorily at 75 r.p.m. compressing only the high-pressure gas—that is, operating as any ordinary ammonia compressor; but when the two gases were admitted—that is, when running multiple-effect—a speed above 45 to 48 r.p.m. was prohibitive on account of the valves' slamming. Mr. Fairbanks contended that to use a V-port in the cylinder sufficiently long to admit the gas gradually enough to avoid serious impact would necessitate the cylinders being at least 6 in. longer, and this he regarded as not worth while. The valve areas, suction and discharge, are much more than those ordinarily used on standard machines, and these valves are provided with buffer springs and dashpots and are also very light to avoid troubles due to inertia. To run the compressor therefore at a speed suitable to the multiple-effect compression meant more of a loss than a gain. Mr. Fairbanks stated that, from experience and experiments at his plant, they would not again consider a multiple-effect system. Asked if the system was any good at all, Mr. Fairbanks replied in the affirmative.

## PERSONALS

Benjamin B. Lawrence, a member of the class of '78, has purchased the Pelton-Doble water wheel and the Pelton-Francis turbine, which were exhibited by the Pelton Water Wheel Co. at the Panama-Pacific International Exposition, and presented them to the Columbia School of Mines.

F. W. Ballard, Light and Heat Commissioner, of Cleveland, under whose administration the municipally owned electric system has been so successfully extended, will be detached from this field, in which he has been so successfully useful, as the result of the recent election, and will establish himself as a consulting engineer, with headquarters in the Swetland Building, Cleveland, in an association which will be known as F. W. Ballard & Co., Engineers. The work to which particular attention will be given will be the building and operation of municipal electric light and power plants, representing municipalities in the hearing of rate cases before public-utilities commissions, and the making of appraisals of public-utility properties, also representing municipalities in negotiations with electric light and power companies for lighting contracts and franchises in consideration of reduced rate schedules. The City of New Orleans has recently secured a rate reduction from a maximum of 12c. to 7c. per kw.-hr., with a saving to the city of over $300,000 per year, with Mr. Ballard's assistance. It is also the intention to make appraisals of industrial properties and to design and build factories and industrial plants generally.

## ENGINEERING AFFAIRS

**The Hotel McAlpin,** New York City, will be the headquarters for the thirtieth annual convention of the American Order of Steam Engineers in the early part of June next.

**The New England Association of Commercial Engineers** held a luncheon meeting at the Revere House, Boston, Dec. 11. Walter B. Snow gave a brief talk on "Advertising—General and Specific."